383

Krishi : Production, Processing and Marketing

BOOK-1

383KRISHIB1

विद्याधनं सर्वधनप्रधानम्

NIOS

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NIOS SENIOR SECONDARY - KRISHI (383)

Complete Textbook (25 Lessons)

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EVOLUTION AND DEVELOPMENT OF AGRICULTURE

Agriculture originated thousands of years ago. Since then it has served as catalyst for evolutionary change in humans. In the history of human society, there has been a profound shift from a nomadic hunter-gatherer existence to a settled way of life. It was only made possible by the invention and adoption of early agricultural practices. There were many forms of ancient agriculture like 'Sumerian Agriculture' of Sumer (at present day Iraq), 'Aztec and Maya Agriculture' in Mesoamerica (at present day North America), 'Roman Agriculture' (at present day Rome), 'Chinese Agriculture' (at present day China), and 'Indian Agriculture'. In this lesson we will learn about development of agriculture over a period of time and significant achievements of India in agriculture sector.

LEARNING OUTCOMES

After studying this lesson, the learner:

- recognizes how agriculture was gradually developed from ancient times to modern era;
- explains the reasons for backwardness of Indian agriculture during British period;
- identifies the role of 'Green Revolution' in alleviating hunger from India; and
- distinguishes the achievement of India after independence in agriculture sector.

1.1 ORIGIN AND EVOLUTION OF AGRICULTURE

The English word agriculture is originated from the Latin word 'ager' (meaning –field) and 'cultura' (meaning – to cultivate). When combined, the word 'agriculture' means cultivation of field. Agriculture can be defined as the art and science of cultivating the

soil, producing crops, raising livestock as well as preparation and marketing of the resulting products. Therefore, agriculture can be summarised in many ways. Crop plants and domestic animals sustain the human population by providing food and other products.

Primitive man collected wild fruits, grains, other natural products and consumed them as food. Around 12000 years ago, agriculture was first emerged which led to a significant change in human behavior. Due to this, life style of people changed from a nomadic life to a settled life of farming and permanent communities. Different regions of the world saw the independent emergence of agriculture. There were at least 11 different regions in the world evolved as independent centres of origin for various crops.

- On the beaches of the Sea of Galilee, the Ohalo II people were the oldest known inhabitants to have practised small-scale cultivation of edible grasses during dates back 21,000 BC.
- The Levant (a large area in the Eastern Mediterranean region of Western Asia) was home to the eight Neolithic founder crops by about 9500 BC. It included emmer wheat, einkorn wheat, hulled barley, peas, lentils, bitter vetch, chickpeas, and flax. Wheat was the first to be grown and harvested on a significant scale.
- On the banks of the Nile, farming had become established by 8000 BC.
- Around this period, independent agricultural development took place in the Far East, most likely in China, with rice replacing wheat as the main crop. The earliest evidence of cultivation of rice is found in China at 5700 BC. The millet became the main crop of the Yellow River basin in China by 5500 BC that was domesticated by early Sino-Tibetan speakers at around 8000 to 6000 BC. Thereafter, mung, soy, and azuki beans were also domesticated in China by 6200 BC. Rice cultivation had later extended to South-East Asia around 3,500 to 2,000 BC.
- By 6700 BC, the wild grass Teosinte in southern Mexico had been domesticated into maize. In the New World, domesticated plants included the potato (8000 BC), tomato, pepper (4000 BC), squash (8000 BC), and several varieties of bean (8000 BC onwards).
- Sheep and pigs were the first domesticated animals in Mesopotamia roughly 11,000 years ago. In the regions of present day Turkey and India, cattle were domesticated during 8500 BC. It took a long time to domesticate camels, possibly around 3000 BC.

Ancient civilizations, such as Mesopotamian Sumer, Egypt, the Indus Valley civilisation of the Indian subcontinent, ancient China and Greece had experienced an intensification of agriculture during the Bronze Age, which began around 3300 BC. During the Iron Age, the ancient Rome was expanded throughout the ancient Mediterranean and Western Europe. The manorial system, which served as the foundation of medieval agriculture, was established during the classical era of antiquity of Rome (8th century B.C. to 5th century A.D.).Through introduction of improved methods and new crop plants, such as sugar, rice, cotton, and fruit trees like orange, agriculture was altered during the medieval period in both Europe and the Islamic world.

Notes

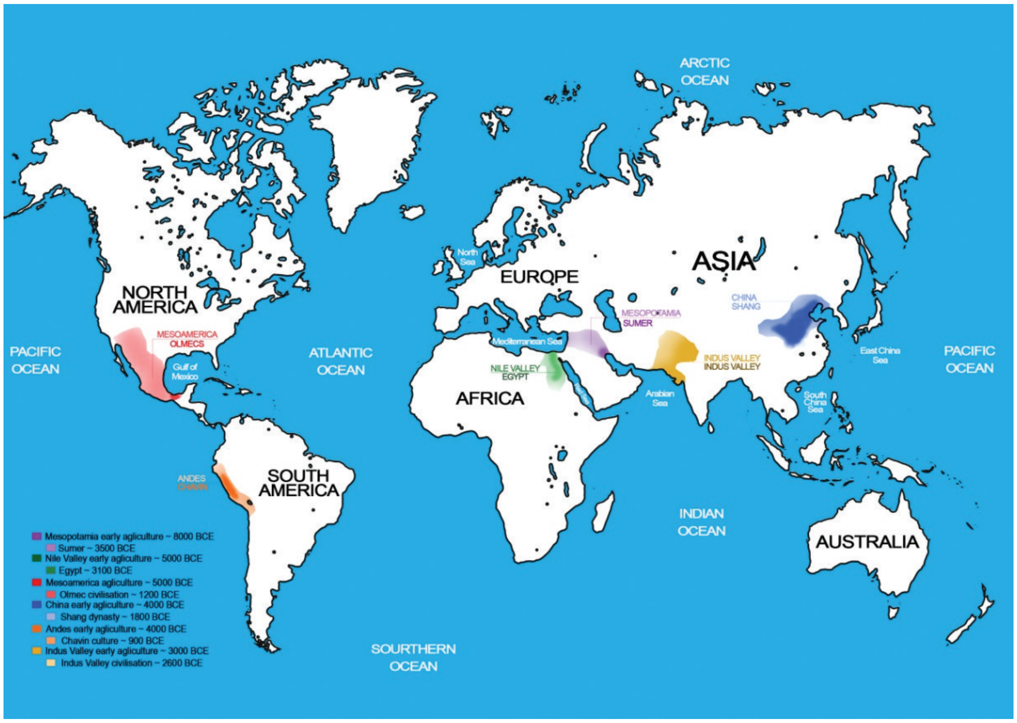

Fig. 1.1: Earliest civilizations of the world

Following the Neolithic Revolution, the 'British Agricultural Revolution' marked the beginning of a 200-year period of rapid advancement with the development of irrigation, crop rotation, and fertilizers.

Since 1900, agricultural productivity has increased significantly in developed countries, and to a lesser extent, in developing countries due to mechanization, aided by synthetic fertilizers, pesticides, and selective breeding.

Notes

INTEXT QUESTIONS 1.1

1. The word agriculture is derived from which language?
2. How many centres of origin are believed to be existed?

   a. 5   b. 7

   c. 9   d. 11
3. Agriculture first emerged around 12000 years ago (True/False).
4. .... was the wild relative of maize and was domesticated in area of ....
5. Earliest evidence of cultivation of rice was found in

   a. Mesopotamia \   b. Egypt

   c. China   d. Rome

ACTIVITY 1.1

You have read that before emergence of agriculture, human was hunter and gatherer. You must have seen few glimpses of these ancient men in your history book. Can you visualize their daily life? Imagine how they satisfied their hunger. Discuss and share your thoughts with parents and friends.

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1.2 NEOLITHIC REVOLUTION

After emergence of agriculture around 12000 years ago, it caused rapid shift in people's lifestyle and human society. This advancement is known as the 'Neolithic Revolution'. V. Gordon Childe coined the term 'Neolithic Revolution' in 1936.The Neolithic Revolution began in the Fertile Crescent in Near East (a region covering modern day eastern Turkey, Iraq, and south-western Iran). Agricultural growth improved living of people. It changed from a hunter-gatherer way of life to farming and permanent settlements. These permanent settlements gave emergence of cities and civilizations.

Notes

This shift in human lifestyle also impacted the agricultural environment. Because of this advancement, it was now possible to raise crops and animals to meet demand of food. Thus the world's population increased.

Human societies underwent a number of changes as a result of the Neolithic revolution which are depicted in figure 1.2

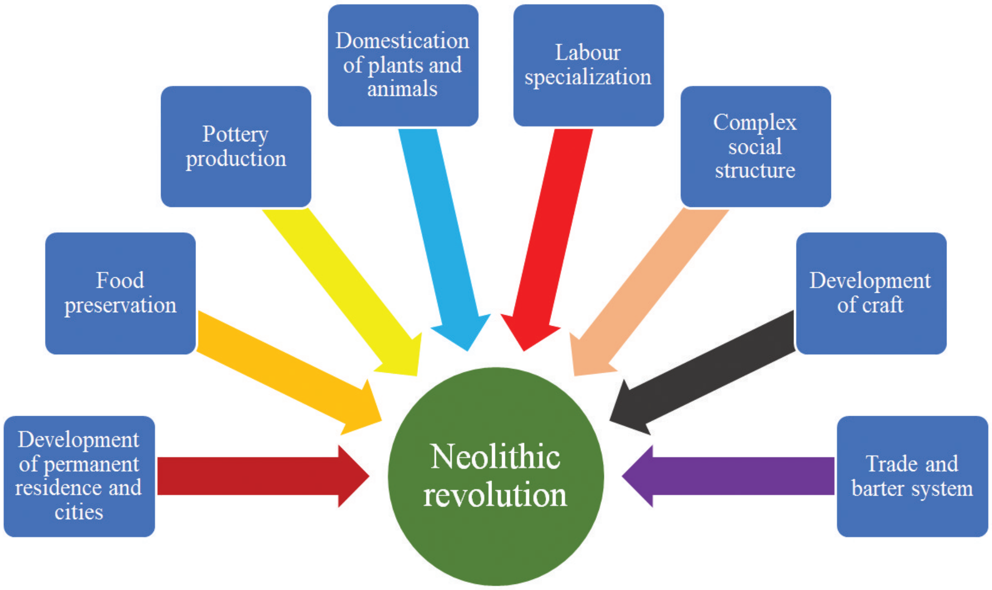

Fig. 1.2: Characteristics of Neolithic revolution

In different places of the world, people began farming for a variety of reasons.. It is believed that there was a major climatic shift at the end of the last ice age in the Near East. Such change in seasonal conditions benefitted annual plants like wild grains. Increased pressure on the natural food resources in other places, such as East Asia, might have compelled individuals to come up with their own remedies. But, there is no doubt that farming initiated the development of primitive men regardless of its independent beginnings.

Domestication of Plants and Animals

The definition of domestication is simply "to put plants or animals under human control or tame". Domestication has made life easier for humans by providing food, labour, other products, and companionship.

A. Plant Domestication

Wheat, barley, and peas are the crops whose wild ancestors were found throughout the Near East region. Rice and millet farming both have their roots in China's Neolithic era. The earliest known rice fields in the world were found in

Notes

eastern China, and they give proof of early farming methods including flood and fire control.

Through this process, many behavioral features between wild species and current domesticated populations have evolved. For example, the grains of wild plant species like wheat, barley, and rice frequently fall on the ground before they are fully matured, thus making their harvesting difficult. However, when cultivation and irrigation practices were developed, many of these plants' natural characteristics were lost. With careful attention from the early farmers, yields finally improved. The Neolithic farmers chose cultivars that could preserve seeds for mature harvesting for a longer period of time.

B. Animal Domestication

The beginning of the domestication of formerly hunted animals is another significant part of the Neolithic revolution. Cattle, goats, sheep and pigs were originated as domesticated animals in the Fertile Crescent of Near East region. Factors, such as the animal's size, temperament, food, mating habits, and lifespan governed the domestication process. Ability to plough and utility as a food source were the most important considerations for selection of animals.

In early Neolithic civilizations, these animals provided a significant portion of the food and protein. Milk, a significant source of protein, was produced by animals like cows and goats. Some animals also produced materials such as leather, wool, skins, and fertilizer.

Technological Achievements during Neolithic Revolution

New technologies were created as a result of the need for improved tools and weapons to support the new way of life. Neolithic people first made tools for agricultural use, and later they created metal-working techniques to meet their needs. One of the key features of Neolithic civilisation is the invention of pottery. The wheel is considered a remarkable achievement of the Neolithic Period. The wheel's invention allowed people to carry heavy loads and made transportation faster and easier. It saved the primitive human's time that they could use for other activities.

The Neolithic period marked the beginning of man's production of ground and polished stone tools, also known as Celts. These axes and adzes were presumably used to cut trees and break up the land so that it could be utilized for farming. Celts with pointed ends may have served as hoes or ploughs. Most likely, several of these tools were also employed for tilling the soil in addition to clearing the land.

Various locations throughout the world experienced the Neolithic Revolution in unique and separate ways. In the Near East, pottery emerged after agriculture, whereas in Japan, pottery advanced significantly before agriculture. Ploughs, tools, methods of seed selection, and irrigation systems were only a few of the technical advancements that were directly related to agriculture and developed at a faster rate as the towns grew.

Model of David Harris on The Origin of Agriculture

David Harris provides a four-stage transition paradigm from hunting-gathering to agriculture.

1. **In the first stage,** hunters and gatherers gather and protect beneficial plants and fruits, periodically burn the unwanted vegetation to reduce competition between plants, and lessen soil disturbance. At this point, the environment is not being significantly transformed or being significantly influenced on a broad scale by human activity. This type of wild plant-food economy is a development from even earlier hunting lifestyles.

2. **The second stage,** which may be seen as a crucial step toward agriculture, is characterised by the cultivation of wild plant-food with some ploughing. Planting, seeding, and weeding of wild plants were used to maintain plant populations in their natural state. Men planted seeds from a few carefully chosen plants with favourable traits in new environments, and some of the harvested seeds were saved for later use.

3. **The third stage,** in which the ground was cleared and food-producing operations like planting, weeding, plant propagation, etc. were carried out extensively. Systematic tillage of land is a major characteristic of this stage. The plants underwent significant morphological and genetic alterations as a result of meticulous care. Care increased the number of seeds, which caused an increase in output. In terms of food, this might allow a sizable number of human groups to reside continuously in one location.

4. **'The fourth stage'** The development of new, highly energy-intensive technologies for food production is considered the ultimate step. Initially, men selectively cultivated plants, choosing those that produced more. This energy-intensive stage ultimately led to the emergence of new genotypes that meet human requirements more effectively.

Notes

INTEXT QUESTIONS 12

1. The transition from a nomadic hunter-gatherer way of life to farming and permanent settlements is known as ....
2. Who coined the phrase 'Neolithic Revolution'?
3. What is Domestication?
4. What was known as man's production of ground and polished stone tools?
5. Periodical burning of vegetations to lessen plant competition was seen in .... stage of agricultural development.

ACTIVITY 1.2

You have studied about ancient civilizations in preceding section. Have you noticed that all these civilizations flourished near the banks of river? Can you think any reason for this? Write down your thoughts.

....

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....

1.3 HISTORY OF AGRICULTURE IN INDIA

As we have seen in the Neolithic Revolution, Indian agriculture also transformed from a nomadic way of hunting and gathering to farming in permanent settlements. Let's discuss this development through different eras.

Pre-Vedic Era

In the Indian subcontinent, agriculture started as early as 9000 BC, and around that time, crops like wheat, barley, and jujube were domesticated.

A. North India

The knowledge of crop production as a component of the agricultural system grew more clearly during the "Indus Valley" civilization, also known as the "Harappan civilization". It existed between 2300 and 1600 BC in the western

Punjab and Sind regions of the Indian subcontinent. Eastern Punjab, western Uttar Pradesh, Rajasthan, western Madhya Pradesh, and Gujarat were eventually colonized by the "Harappan" culture.

- Their agricultural system included the cultivation of wheat and barley. As both the crops had originated in central Asia, it was determined that the "Indus Valley" and the "Mesopotamian" civilizations had interaction.
- Chickpea, a pulse, was found at the Harappan site, and sesame, an oilseed, possibly imported from Mesopotamia or Africa, was also grown there during the Harappan civilization.
- Mustardseeds (*Brassica juncea*) were also found at the Chanhu-daro site, indicating its growth in Sindh.
- A small piece of Mohenjo-daro cotton fabric revealed that the Indus Valley civilization was the first to spin and weave cotton fibers. The principal goods exported by the Harappans to Mesopotamia were cotton fabrics, which they traded for money and woolen clothing.
- Evidence of fruit availability during the Harappan civilization indicates the cultivation of dates, lotuses, coconuts, pomegranates, lemons, and melons.

B. South India

- The evidence of cultivation from Hallur, Karnataka indicates that ***ragi*** (1800 BC) was a preferred crop in the southern peninsular region. **Horsegram** grains (1780–1500 BC) were found at Tekkalakota, Karnataka, and are considered a pulse.
- The grains found in Maharashtra also suggest growing a number of **small millets**. **Lentil**, **greengram**, and **blackgram** were all cultivated as agricultural crops around 1500 BC at Navdatoli in Tamil Nadu. In addition, **sorghum** was grown among the millets; **linseed** and **castor** were grown among the oilseeds; ***ber*** and ***amla*** were grown among the fruits.

Vedic Era

Add this sentence - During this period, Eastern Afghanistan, the North West Frontier Province, Kashmir, Punjab, and portions of Sind and Rajasthan were all under the control of the Aryans. These area got its name "Saptasindhavah" from the seven rivers Sutlej, Beas, Ravi, Chenab, Jhelum, Indus, and Saraswati that flow through this fertile land.

- The Rig-Veda, the oldest literature of the Aryans, mentions barley, white- and black sesame, sugarcane, cucumber, and bottle gourd during the early Vedic era (1500–1000 BC). Although Harappans grew wheat and cotton, the early Aryans might have stuck to barley as their staple diet in their own area.
- Early Vedic literature does not contain any references to rice. It was only after they established their dominion into Uttar Pradesh and Bihar that they learned about rice.
- Sama-Veda, Yajur-Veda, and Atharva-Veda were among the Vedic literatures that were written between 1000 and 600 BC, during the later Vedic periods. The Mahabharata and the Ramayana were also written at same time. These writings make reference of farmed and wild rice, barley, wheat, maize, *bajra*, foxtail millet, proso-millet, barnyard millet, kidney beans, lentils, sesame, and coix.
- Two crops were typically grown each year. Barley was sown in the winter and reaching maturity in the summer, while rice was planted in the rainy season and harvested in the autumn. When the summer rains started, beans and sesame were planted, and they were harvested in the winter's colder months. It's also possible that cucumber was grown during that period.

Agriculture during Ancient Dynasties

- **The *Magadha* Empire (544-492 BC):** They ruled over territories in eastern India. Rice was their preferred cereal crop and pulpy rice was served as the main course.
- **The *Mauryan* dynasty (322-232 BC):** During the reign of *Ashoka* (274–237 BC), the plantations of banana, mango, jackfruit, grape, and date palm were developed.
- ***Sungas*, *Satvahanas*, and *Kushan* Empires (200 BC-200 AD:** Coconuts are often cultivated in coastal regions as it can be used for copra, oil, oilcake, fibre and several other purposes.
- ***Pandyas*, *Cheras*, and *Cholas* (1st century Christian era-300 AD):** Bamboo, rice, jackfruit, *ragi*, sugarcane, pepper, turmeric, and cotton were cultivated at various regions of southern India dominated by these dynasties.
- ***Gupta* era (300–550 AD):** Cultivation of red rice, yellow rice, and hog's rice were mentioned. *Sali* rice's ability to grow suggested that they were familiar with the process of transplanting rice. Other crops were also grown, including

vegetables (cucumber, onion, pumpkin, and gourd), cereals (rice, wheat, and barley), pulses (peas and lentil), oilseeds (sesame, linseed, and mustard), spices (pepper, cardamom, cloves, ginger, and turmeric), and fibre crops (cotton, flax, and hemp).

? DO YOU KNOW

Sali is a type of rice specially grown in winter months. It is a tall and late maturing variety which contains many medicinal properties for curing piles, skin burn, haemorrhoids bleeding, anemia.

- **Empire of Harshavardhana (606–647 AD):** A Chinese traveller Hiuen Tsang travelled to Kanauj, the capital of Harshavardhana. In his travelogue Si-yu-ki, a 60-day mature rice cultivar was specifically mentioned. He added that there was another rice cultivar with a remarkable smell. Hiuen Tsang's student Shaman Hwui Li described a unique type of rice with huge seeds that smelled strongly of black beans.

- ***Chalukyas, Rashtrakutas, Pallavas, Pandyas, Hoysalas*, and *Kakatiyas* (535-1300 AD):** They controlled southern India. Millets were only grown in the Deccan and Mysore plateau's rainfed regions at that time, whereas rice farming was expanded to a number of sites with available irrigation infrastructure. In addition, the entire territory was used to cultivate sugarcane, sesame, ginger, pumpkin, yam, mango, coconut, and jackfruit.

- **Reign of Rajputs, Palas and Senas:** Between 650 and 1155 AD, several ***Rajput*** emperors governed north India, while Bengal was ruled by ***Palas*** and ***Senas*** between 760 and 1205 AD. Eight varieties of rice with various colours, scents, sizes, and growing seasons have been mentioned in Sanskrit writings. While rice was a staple food of the royal diet in Kalinga and well-known in *Magadha*. There were many of coconut, ginger, and cinnamon trees. Different kingdoms also cultivated cotton and indigo.

- **The literature of *Medhaitithi*, *Parashara*, *Kashyapa*, and early Arabs (900-1100 AD):** According to their texts, rice, mangos, coconuts, and lemons were cultivated in significant amounts and sugarcane, pepper, and bamboo grew in special regions. *Kashyapa* gave clear explanations of the cultivation of rice and its transplanting, weeding, irrigation, crop protection techniques, harvest, threshing, seed selection, and storage.

- **The Delhi Sultanate (1206–1526 AD):** The Islamic Empire controlled a sizable portion of the Indian subcontinent. *Ibn Battuta* provided a thorough description of the crops that were farmed at this time. The crops were planted twice a year, once in the spring and once in the summer when rain occurred.

- **The Vijayanagara Empire (1336–1646 AD):** Field crops grown at this time included rice, wheat, *jowar*, barley, beans, greengram, and horsegram, while fruit crops included sweet and sour oranges, wild brinjal, pomegranate, and grapes.

- **The Portuguese:** Through marine routes that passed through Portugal, Brazil, Cape of Good Hope, and Goa in India, the Portuguese brought new American and African crop plants to the country. The newly introduced crops were tomato, maize, papaya, guava, groundnut and tobacco. In the sixteenth century, the Portuguese brought chillies from Brazil or Peru to India, and in the seventeenth century, they brought potatoes from Chile or Peru. They also made a huge contribution by developing the 'grafting' process in 1550.

Mughal Era

A. **Babur:** Babur's invasion in 1526 marked the beginning of the *Mughals'* power in India. Various crops like mango, banana, tamarind, *mahua*, *jamun, chironji*, jackfruit, *ber*, *amla*, lime, orange, date palm, coconut, and toddy palm were described by Babur in his autobiography, the *Babur-nama*. He also described the availability of certain exquisite flowers like white jasmine, oleander, and gurhal. It is said that Babur brought the fragrant Persian rose to India.

B. **Akbar:** The *Mughal* Empire was controlled by *Akbar* from 1555 to 1605. *Abu'l Fazl*, the court historian of *Akbar*, and several other European travellers provided extensive descriptions of the crops, flowers, and fruits that were grown there during Akbar's administration. These texts noted that while barley and chickpeas were planted throughout, wheat was mostly grown in India's north-western region. Chickpea, lentil, pea, greengram, blackgram, and arhar (pigeonpea) were the most common pulses. The oilseed crops farmed during that period included sesame, linseed, toria, mustard, and safflower. In addition, tobacco, sugarcane, cotton, hemp, indigo, poppies, betel nuts, melons, gourds, and pumpkins were all grown. In Kashmir, saffron was grown. According to *Abu'l Fazl*, Bengal had the biggest sugarcane production.

C. **Shah Jahan:** A better kind of cherry, peach, plum, and grape was imported from Persia and Afghanistan under the reign of Shah Jahan (1628–1658).

British Era

The East India Company had come to India for trading. But after the Battle of Plassey in 1757, they began to govern over substantial portions of the country. At that time ginger, saffron, cardamom, pepper, cocoa, and other palm-yielding nuts were the main spices consumed by the native Indians. Mango was considered the best fruit all over India. Pomegranate, citron, date, almond, grape, pineapple, and tamarind were the other native fruits. European fruits, such as apples, pears, plums, and apricots were produced in the northern regions.

- The local artisans of India used to transform the short staple and coarse cottons into very fine yarns. In order to meet the demands of the Lancashire textile industry of Great Britain, the Governor General of Calcutta promoted the growth and improvement of Indian cotton.
- In the 18th and 19th centuries, the British attempted to modernise Indian agriculture by introducing new crops, institutions, and processes. But main aim behind this modernization was to improve businesses of East India Company. Rice, cotton, indigo, opium, and other agricultural products from British India became important commodities in the world trade.
- The amount of cultivated land significantly increased in the second half of the nineteenth century. A consistent increase in yield per acre was also observed as new crops became exportable. Agriculture significantly expanded in the region of Punjab, the Narmada valley, the western portion of the United Provinces, and coastal Andhra Pradesh.
- During the period of war, food availability decreased significantly. Frequent famines were observed all over India. Bengal saw the worst effects of the crisis.
- Wide scale improvements to Indian agriculture began during the second part of the 19th century. A department of agriculture was established in India in 1871. But the department rarely did anything for improvement of agriculture beyond data collection and famine relief report. Therefore, government decided to create a central "Department of Agriculture" as well as agriculture departments in the provinces. This department was empowered to handle agricultural research, agricultural development, and famine relief in the nation.
- Following the catastrophic famines of 1899–1900, Lord Curzon, the Viceroy of India at the time, determined to establish colleges for agricultural training. As a result, the Agriculture Research Institute for advanced agricultural training was established in Pusa, Bihar in 1905.

- An All India Board of Agriculture was founded in 1905 to provide useful advice for improvement of agriculture to the government. The Indian Agriculture Service was also established in 1906.

INTEXT QUESTIONS 1.3

1. Agriculture started in India around ....
2. Which crop was used as staple diet by early Aryans?
3. Name any two crops introduced by Portuguese in India.
4. For the promotion of trade and commerce, the British East India Company encouraged the cultivation of

   a. Cotton b. Indigo

   c. Opium d. All of these

ACTIVITY 1.3

You must have taken the tomato sauce/chutney or chillies in your daily meal. Have you wondered by knowing that such crops like potato, tomato, chillies are not Indian origin? The Portuguese bought these in India. Before introduction of chilli, traditionally Indians used another crop for making similar flavour. Can you name this crop?

....

....

....

1.4 BRITISH AGRICULTURAL REVOLUTION

The British agricultural revolution was a remarkable increase in agricultural production in the Britain. This revolution is also known as the second agricultural revolution. This was caused due to efficient use of land and labour in mid 17^{th} and late 18^{th} centuries. Such rise in agricultural productivity declined the need of additional labour on agricultural land. These additional labours then contributed to the development in industries in urban areas. Therefore, the British agricultural revolution is considered as cause of industrial revolution in Europe.

The British Agricultural Revolution was the result of the complex interaction of social, economic and farming technological changes. The major agricultural developments and innovations in this period include:

- Norfolk four-course crop rotation
- Modification of the Chinese plough to allow it to be pushed by fewer oxen or horses
- The abolition of common rights on land and establishment of exclusive ownership of land.
- Growth of a national market free from tariffs, tolls and customs barriers
- Improvement of transportation infrastructures, such as enhanced roads, canals, and later, railways
- Land conversion and reclamation
- Construction of field drainage structures
- Increase in farm size
- Selective breeding

The second revolution could be divided into three stages:

1. The **first stage** of this revolution is transition from subsistence farming to cash farming for the market. At this stage, mostly the previous practises of cultivation and the physical layout of farms were preserved.

2. The **second stage** involved the technical changes of crop rotations and livestock improvement. It also typically involved abolition of common rights on land or enclosure. Farmers were more market-oriented in choosing which crops to raise, when to raise and in what quantities.

3. In the **third stage**, tractors replaced horses and a variety of machines like mowers, reapers, binders, tedders, and threshers replaced human labour. In addition, farmers began using fertilizers which made possible to grow cereal crops continuously.

As a result of these advancements, farm resources were being used in more efficient, rational and orderly manner. Farmers are benefitted from better yield and higher income per unit of land.

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Norfolk Four-course Crop Rotation

Crop rotation is the successive cultivation of different crops in a definite order on the same fields. Norfolk four-course crop rotation system is sequential growing of four crops in four year cycle on a same piece of land. This was created in Norfolk County, England and popularized by British agriculturist Charles Townshend.

Wheat was planted in the first year of the Norfolk four-course system, turnips in the second, barley in the third and clover as well as ryegrass were sown in fourth year. The ryegrass and clover were grazed or harvested for fodder. Turnips were fed to sheep and cattle throughout the winter. The soil was nourished from the sheep's excreta during grazing in fields. Subsequently, it encouraged greater crop harvests in following years. The benefits of this new system were increased availability of fodder crops for livestock's consumption and abundance of animal manure.

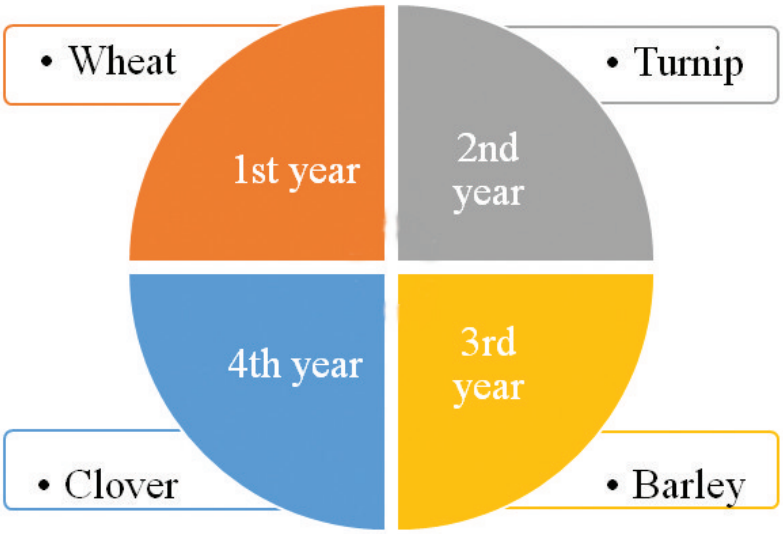

Fig. 1.3: Norfolk four course crop rotation

INTEXT QUESTIONS 1.4

1. Unprecedented rise in agricultural production in the Britain is termed as ....

2. Enlist the major change in approach toward farming during second agricultural revolution.

3. Replacement of manpower and animals by machines took place in which stage of British Agricultural Revolution?

4. Which fodder crop was cultivated in the Norfolk four-course crop rotation system?

   a. Maize   b. Clover

   c. Napier grass   d. Lucerne

Notes

1.4 GREEN REVOLUTION

The 'Green Revolution' or third agricultural revolution was a period of great increase in food production (especially rice and wheat) due to introduction of high yielding varieties of crops. These new varieties required large amounts of fertilizer and pesticides for higher production. The first achievements of 'Green Revolution' were observed in Mexico and the Indian subcontinent. Green Revolution was initiated by Norman E. Borlaug in the 1960s. He is renowned as the 'Father of the Green Revolution' while M.S. Swaminathan was the leading architect of India's Green Revolution.

The Bengal Famine occurred in India during 1943. It affected approximately 4 million people in eastern India. As population growth was exceeding food production, the government emphasized the development of agriculture in India. This required urgent and aggressive efforts to boost production and the 'Green Revolution' served as the catalyst for this action.

Fig. 1.4: Severity of the Bengal Famine (1943)

During 'Green Revolution' which occurred between 1967-68 and 1977-78, Indian agriculture transformed into an industrial system. It adopted modern methods and technology, such as the usage of High Yielding Varieties (HYV) seeds, tractors, irrigation systems, pesticides, and fertilizers. This initiative was sponsored by the U.S. and Indian governments, as well as the Ford and Rockefeller Foundations.

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This revolution transformed India from a food-deficient country to one of the world's leading agricultural nations. In India, the 'Green Revolution' significantly increased agricultural productivity, especially in irrigated areas and in states like Haryana, Punjab, and Uttar Pradesh. The development of high-yielding wheat seeds and rust-resistant wheat strains were significant achievements in this effort. Between 1967-68 and 2003-04, wheat production increased more than three-fold, while cereal production increased by two times.

Basic Elements of the Green Revolution

I. **Expansion of farming areas:** Although the cultivated land has been increasing since 1947, it was insufficient to meet rising demand. The 'Green Revolution' helped in the expansion of land under cultivation**.**

II. **Double-cropping System:** As there is only one rainy season in a year, the practice of one crop per year was prevalent. Double cropping was a chief feature of the 'Green Revolution' where two crops were being cultivated per year.

III. **Using seeds with improved genetics**: Use of superior quality seeds was the another characteristic of the 'Green Revolution'. The Indian Council for Agricultural Research (ICAR) introduced new strains of high yield variety seeds, primarily wheat, rice, millet, and maize.

Overall, the green revolution played a significant role in providing food security for developing nations like India.

Drawbacks of Green Revolution

Apart from food security, little attention was paid to the environment and economic condition of farmers during green revolution. As a result, several negative effects are being felt at present times. These are as follows:

- Pollution of soil, water and air due to excessive use of fertilizers and pesticides
- Reduction in biodiversity of cropland due to preference of few high yielding crops by farmers
- Depletion in ground water resources as new crops have higher water demand
- Deterioration of soil quality and fertility
- High cost of inputs, such as seeds, fertilizers, and pesticides has led many farmers to fall into debt. Small and marginal farmer cannot afford these inputs while big farmers can easily make profit. As a result, disparity between farmers increased.

Notes

The Evergreen Revolution

The benefit of 'Green Revolution' came at the expense of adverse environmental effects. Start the paragraph with this highlighted sentence and keep the present first sentence as second sentence. As a result, Dr. M.S. Swaminathan, India's Father of Green Revolution, emphasised the necessity for 'Evergreen Revolution'. The 'Evergreen Revolution' envisions increased production with protection of environment. The agricultural practices should be ecologically safe, economically viable, and socially sustainable. The evergreen revolution recommends the incorporation of ecological concepts into the creation and spread of technology.

Other Revolutions in Agriculture

Apart from 'Green Revolution', India also witnessed increased production/revolution in several other allied sectors of agriculture. These are in as indicated below:

White Revolution:	Milk Production
Yellow Revolution	Edible oil (oilseeds) production
Blue Revolution:	Fish Production
Brown Revolution:	Food Processing
Grey Revolution:	Fertilizer Production
Red Revolution:	Tomato/Meat production
Pink Revolution:	Prawn/Onion production
Golden Revolution:	Fruit Production
Silver Revolution:	Egg/Poultry production

Norman Ernest Borlaug

(25th March, 1914 - 12th September, 2009)

Dr.Norman Ernest Borlaug was an American plant pathologist, widely known as 'Father of Green Revolution'. Born in Cresco, Iowa, USA at Norwegian immigrant family. From childhood, he actively participated in football, baseball and wrestling teams at Cresco High School. He obtained his B.S. degree in forestry in 1937, M.S. (1940) and Ph.D. in Plant Pathology & Genetics (1942) from University of Minnesota. After that he joined CIMMYT, Mexico as an agricultural scientist where he developed semi-dwarf, high yielding, disease-resistant wheat

Notes

varieties. These wheat varieties along with modern agricultural practices led to jump in food production in Mexico and other countries, therefore help in achieving food security for billions of people. He was awarded Nobel Peace Prize in 1970 for his contribution. In 2006, Government of India conferred him 2nd highest civilian award 'Padma Vibhushan'. He created an international award called 'World Food Prize' for recognizing exceptional contribution in the field of agriculture. To continue the legacy of Norman Borlaug, Government of India and CIMMYT through their collaborative effort established Borlaug Institute of South East Asia (BISA) in 2011.

M.S. Swaminathan

(7th August, 1925 - 28th September, 2023)

Mankombu Sambasivan Swaminathan, an Indian agricultural scientist and plant geneticist who was the main architect of transforming Indian agriculture during mid 1960s. He was born in Kumbakonam of Madras presidency (present day Thanjavur, Tamil Nadu). Witnessing the tragedy of Bengal famine during 1943, he decided to work for ensuring food security of India. After graduating from Maharaja's College (in Zoology) and Madras Agricultural College (in Agriculture), he went on studying genetics and plant breeding at Indian Agricultural Research Institute (IARI), New Delhi. His contribution in developing high yielding varieties of rice and wheat saved millions of people from famine like situation in South East Asia especially in India and Pakistan. For this leadership role in Indian agricultural movement, he is widely regarded as 'Father of Green Revolution in India'. The United Nations Environment Programme has called him 'The Father of Economic Ecology'. He was the first recipient of World Food Prize in 1987. He had also served as Director General of Indian Council of Agricultural Research (ICAR) and International Rice Research Institute (IRRI). A non-profit NGO trust 'M.S. Swaminathan Research Foundation' (MSSRF) was established by him to promote increased employment of poor women in rural areas.

Verghese Kurien

(26 November 1921 - 9 September 2012)

Verghese Kurien was a pioneer dairy engineer who is widely regarded as 'Milkman of India'. Born in Cochin, Kerala, he was graduated in physics and mechanical engineering. After completing his education, he started working for Government of India as an officer in Dairy Division at Anand, Gujarat.

Looking at the exploitation of local milk producers, he established the Kaira District Cooperative Milk Producers' Union Limited in 1950. Later, it became famous Amul dairy. Amul established a cooperative among the rural dairy producers and facilitated direct communication between them and customers. The dairy cooperative was effective in raising the amount of milk produced. Due to his untiring effort, India has become self sufficient in milk production. He was also the founding chairman of National Dairy Development Board. For his extraordinary achievement, He was awarded with Ramon Magsaysay Award (1964), World Food Prize (1989), Padma Vibhushan (1999).

Notes

INTEXT QUESTIONS 1.5

1. Who is considered as the father of Green Revolution?
2. The Green Revolution in India was led by ....
3. Which organisations sponsored Green Revolution in India?
4. Which of the following state experienced the impact of Green Revolution the most?

   a. Bihar b. Punjab

   c. Assam d. Maharashtra

5. White revolution is related to

   a. Tomato b. Fruit

   c. Milk d. Fish

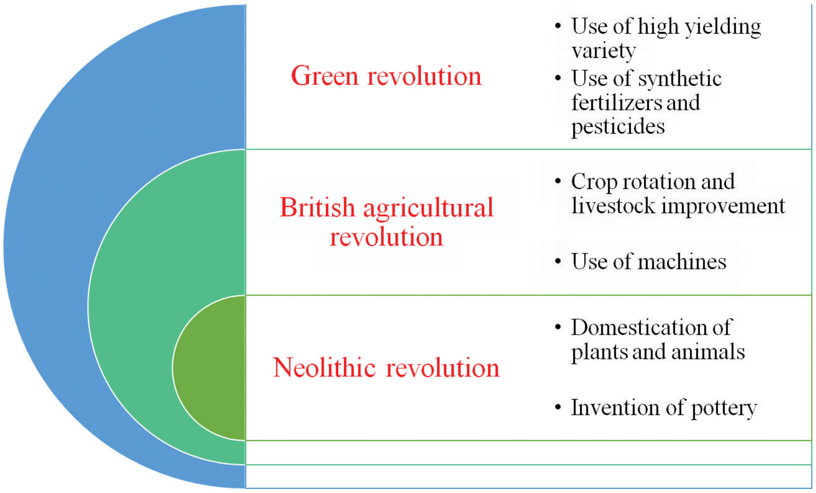


Fig. 1.6: Evolution of agriculture

Notes

Significant Achievements of Indian Agriculture in Post Independence Era

- Transition from food deficient to food surplus country due to green revolution
- Became the top producer of cotton, pearl millet and pulses
- Became second largest producer of rice, wheat, sugarcane, groundnut, rapeseed and mustard
- Introduction of Bt cotton variety
- First nation to develop composite variety of maize
- Development of hybrid variety of pearl millet, pigeon pea, castor and cotton
- Development of biofortified and climate resilent variety of various crop
- First nation to defeat stem rust disease of plant caused by Ug99 race
- Decoding genomic sequence of jute, chick pea, rice and pigeon pea

1.6 HISTORY OF AGRICULTURAL EDUCATION & RESEARCH IN INDIA

Although early agricultural practices were mentioned in Vedas and Upanishads, there was no formal system of agricultural education in India till 1877. First agricultural college in India was established at Saidapet, Tamil Nadu in 1877 which was later shifted to Coimbatore. In 1898, Bengal Engineering College, Shibpur started formal agricultural education programme. Need to establish a large scale education system was felt during beginning of 20th century. As a result, Imperial Agricultural Research Institute (IARI) was established at Pusa, Bihar in 1905 with the donation of American philanthropist Mr. Henry Phipps, followed by establishment of colleges at other places like Kanpur, Nagpur, Lyallpur and Coimbatore in 1906, Pune in 1907 and Sabour in 1908.

Fig. 1.7: Imperial Agricultural Research Institute at Pusa, Bihar

The agricultural education programme of Bengal Engineering College, Shibpur was shifted to IARI with its establishment at Pusa, Bihar in 1905. After synthesis of aniline by Germans for dyeing of cloths in 1899, cultivation of Indigo plants needed to be revived; therefore Pusa in northern Bihar was chosen as the ideal location. Initially it had five departments: agriculture, cattle breeding, chemistry, economic botany, and mycology. In 1907, the bacteriology unit was added. The institute was shifted to Delhi on 19^{th} July, 1936, as a severe earthquake in 1934 completely devastated the institute. After independence, this Imperial Agricultural Research Institute was renamed as Indian Agricultural Research Institute. University Grants Commission (UGC) gave status of Deemed to be University to IARI in 1958 which marked as beginning and restructuring of modern agricultural education in India.

Fig. 1.8: Indian Agricultural Research Institute, New Delhi

When it comes to agricultural research in India, it has started with the establishment of the "Indian Council of Agricultural Research" (ICAR) on 16^{th} July 1929, as a registered society under the Societies Registration Act 1860 following the recommendation of the Royal Commission of Agriculture (1926). The ICAR is the apex body with its headquarters in New Delhi, which coordinates, directs, and oversees agricultural research and education, including fisheries and animal sciences. Being an autonomous organization under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture and Farmers Welfare, ICAR administers 109 research institutes, 63 agricultural universities, 4 deemed-to-be-universities and 731 Krishi Vigyan Kendras (KVKs) spread out across the nation (www.icar.org.in).

After independence, following the pattern of land grant universities in USA, first state agricultural university of India (Govind Ballabh Pant University of Agriculture & Technology) was established in 1960 at Pantnagar, Uttarakhand. Very soon agricultural universities were developed at other places as well like Bhubaneswar and Ludhiana (1962), Jabalpur (1964), Bangalore (1965). At present, there are 63 state agricultural universities spread all over the India.

Notes

Major Events in Development of Agricultural Research System in India

1905	Establishment of Imperial Agricultural Research Institute (IARI) in Pusa, Bihar
1926	The then Viceroy of India Lord Linlithgow formed Royal Commission on Agriculture.
1928	Royal Commission on Agriculture submitted its report where they advocated establishing the Imperial Council of Agricultural Research to encourage, direct, and coordinate agricultural research across India.
16th July, 1929	On July 16, 1929, ICAR was established as a registered society under the Societies Registration Act of 1860 based on the Royal Commission of Agriculture's advice.
March, 1946	Under Jogendra Singh's presidency, it was decided to rename the organisation from the 'Imperial Council of Agricultural Research' to the 'Indian Council of Agricultural Research'.
1960	Establishment of first state agricultural university in India
1965	Dr. B. P. Pal, the first Director General of ICAR, started All India Co-ordinated Research Projects (AICRPs).
1966	ICAR was given full autonomy after the recommendation of Agricultural Review Team.
1973	• In the Ministry of Food and Agriculture, a Department of Agricultural Research and Education (DARE) was established. • In accordance with the Gajendra Gadkar committee's advice, the Agricultural Scientists Recruitment Board (ASRB) was founded on 1st November, 1973 as an independent recruitment organisation. • The Agricultural Research Services (ARS) was initiated.
President of ICAR: Union Minister of Agriculture, Government of India	
1st President of ICAR: Khan Bahadur Sir Muhammad Habibullah	
Director General of ICAR is also the Secretary of DARE.	

INTEXT QUESTIONS 1.6

1. Indian Agricultural Research Institute (IARI) was established during the year of

   a. 1877 b. 1905

   c. 1936 d. 1929

2. The Royal Commission on Agriculture was formed by ....

3. The head quarter of ICAR is located at

   a. Chennai b. New Delhi

   c. Mumbai d. Kolkata

4. Who was the first Indian Director General of ICAR?

5. Initially, the IARI was established at ....

ACTIVITY 1.4

Take a blank world map. Point out places where ancient civilizations were developed. You may take help of figure 1.1 for this purpose.

....

....

....

WHAT YOU HAVE LEARNT

- The agriculture is the art and science of cultivating the soil, producing crops and raising livestock. The word agriculture derives from the Latin words 'ager' (meaning -field) and 'cultura' (meaning - cultivate), signifying cultivation of field.
- Around 12,000 years ago, agriculture began to take root. Farming had become established by 8000 BC on the banks of the Nile. The transition from a nomadic hunter-gatherer way of life to farming and permanent settlements is known as the 'Neolithic Revolution' or first agricultural revolution.

- The process of putting plants or animals under human control or taming is known as 'Domestication'.
- The 2nd agricultural revolution, also known as the British agricultural revolution, took place during the mid 17th and late 18th centuries. The major changes occurred during this phase were shift from subsistence farming to cash farming, technical changes like crop rotation and livestock management, increased use of farm machines and fertilizers.
- Green revolution was initiated during 1960s and late Dr. M.S. Swaminathan is known as the 'Father of Green revolution in India'. The development of high-yielding wheat variety seeds and rust-resistant wheat strains were significant advancements in this effort.
- The Green Revolution transformed India from a food-deficient country to one of the world's leading agricultural nations. The basic elements of green revolution were expansion of farming areas, double cropping system and use of improved quality seeds.
- Indian Council of Agricultural Research (ICAR) is the apex body which coordinates, directs and oversees agricultural research and education in India.

TERMINAL QUESTIONS

1. What do you mean by agriculture?
2. Describe how agriculture contributed to the establishment of permanent civilizations.
3. What are the important features of Neolithic revolution?
4. Give a brief account of David Harris model on the origin of agriculture.
5. Discuss the importance of 'Green revolution' in achieving food security in India.
6. What are the drawbacks of green revolution?
7. Match the followings:

A. White Revolution	1. Food Processing
B. Blue Revolution	2. Fruit Production

C.	Brown Revolution	3.	Fertilizer Production
D.	Grey Revolution	4.	Prawn/Onion production
E.	Red Revolution	5.	Egg/Poultry production
F.	Pink Revolution	6.	Fish production
G.	Golden Revolution	7.	Tomato/Meat production
H.	Silver Revolution	8.	Milk Production

8. Write a short note on 'Evergreen revolution'.

9. Enlist the important steps taken by the British Government to improve the Indian agriculture.

10. What are the major achievements of India in agriculture after independence?

ANSWERS TO INTEXT QUESTIONS

1.1

1. Latin
2. Option d (11)
3. True
4. Teosinte, southern Mexico
5. Option c (China)

1.2

1. Neolithic revolution
2. V. Gordon Childe
3. Domestication is process of adapting plants or animals for human use.
4. Celts
5. First stage

Notes

1.3

1. 9000 BC
2. Barley
3. Potato, tomato
4. Option d (All of these)

1.4

1. British agricultural revolution
2. Four-course crop rotation, modification of Chinese plough, abolition of common right on land, increase in farm size, land reclamation, selective breeding
3. Third stage
4. Option b (Clover)

1.5

1. Dr. Norman E. Borlaug
2. Dr. M.S. Swaminathan
3. Ford and Rockfeller foundation
4. Punjab (Option b)
5. Milk (option c)

1.6

1. 1905 (option b)
2. Lord Linlithgow
3. New Delhi (Option b)
4. Dr. B. P. Pal
5. Pusa, Bihar

GLOSSARY

Agriculture: Agriculture is the practice of cultivating land, raising crops, and rearing livestock. Agricultural activities include poultry, livestock, fisheries, animal husbandry, dairy farming.

Bio-fortification: Biofortification is a process of improving the nutritional value of food crops.

Celts: Celts are prehistoric tools used by primitive human. These were made up of stone or bronze and similar to an axe or hoe.

Domestication: The process of adapting wild plants and animals for human use is called domestication.

Evergreen revolution: It refers to improvements in crop productivity without harming the environment.

New world: The term new world refers to North, Central, and South Americas, including the Caribbean islands. It was popularized when Europeans colonized the America during 16th century.

Norfolk four-course crop rotation: It is sequential growing of four crops (wheat, turnip, barley and clover) in four-year cycle on a same piece of land.

Old world: It refers continents of Asia, Europe and Africa. It is called old because before discovery of America, people believed there were only continents of Asia, Europe and Africa.

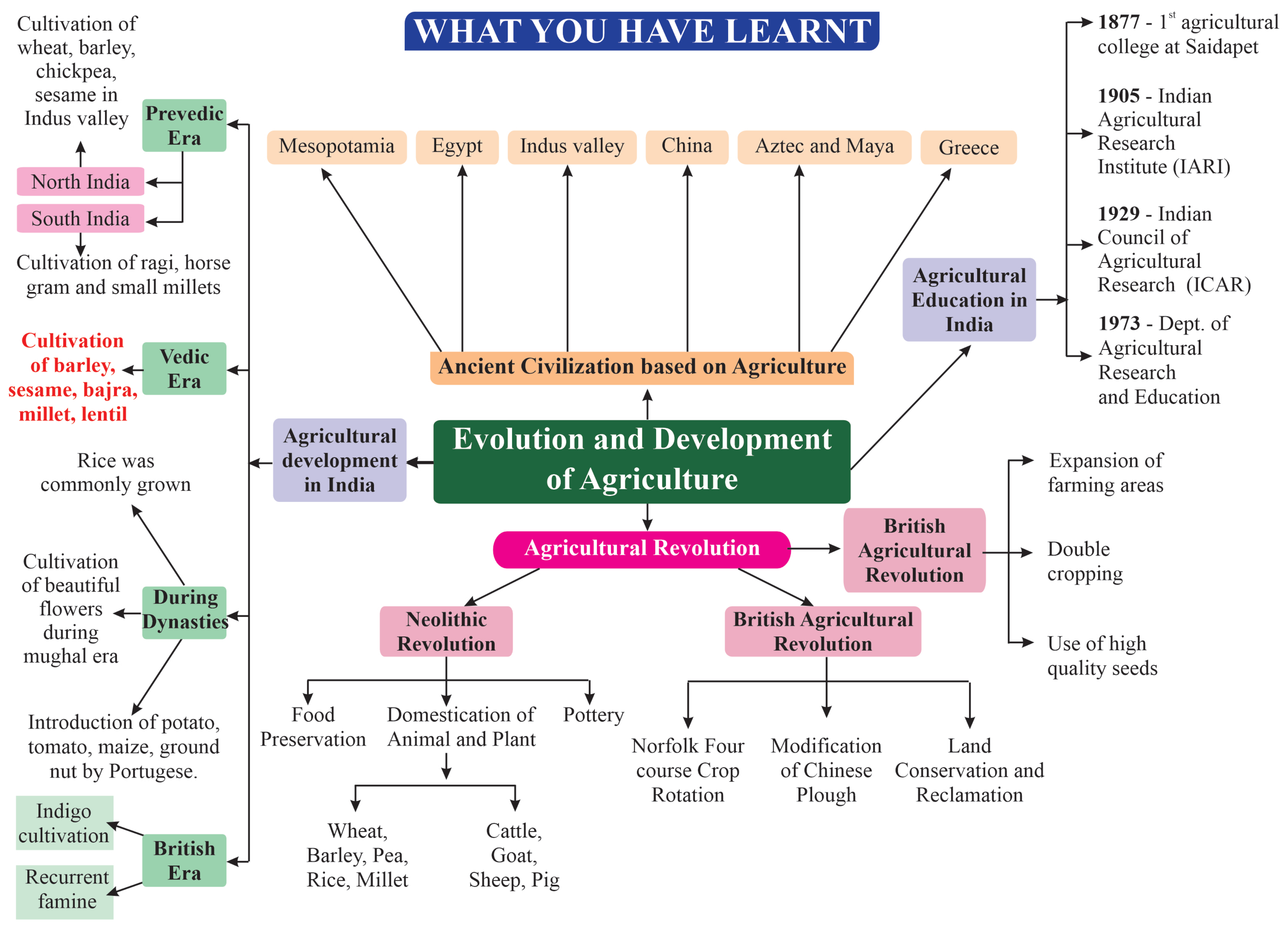
Sali: It is a tall and late maturing variety of rice which contains several medicinal properties. They are specially grown in winter months.

SUGGESTED READINGS

1. Reddy, S. R. (2018). *Agriculture Heritage*, Kalyani Publishers, Ludhiana.

2. Randhawa, M.S. (1980). *A History of Agriculture in India* (Volume I & II), Indian Council of Agricultural Research, New Delhi.

WHAT YOU HAVE LEARNT



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IMPORTANCE OF AGRICULTURE IN INDIAN ECONOMY

In the previous lesson we have learnt how agriculture was developed in India from ancient times. In this lesson you will learn about the importance of agriculture in the economic development of a developing country like India. Many rural households depend on agriculture and agriculture related activities for their income and livelihood. With the concerted efforts of millions of farmers, agricultural scientists, central and state government, the country has been transformed from the food deficit nation at independence to a food surplus and food exporter nation now. Therefore, the growth in agriculture is essential to this country's overall development.

LEARNING OUTCOMES

After studying this lesson, the learner:

- identifies different sectors of Indian economy;
- explains how agriculture acts as source of food, feed and fibre;
- analyzes role of agriculture in supplying raw material to industries; and
- examines how agriculture contributes to employment generation and international trade of our country.

2.1 SECTORS OF ECONOMY

The economy can be broadly divided into various sectors based on the nature of economic activities and the types of goods and services produced. The main sectors of the economy include:

Notes

A. Primary Sector

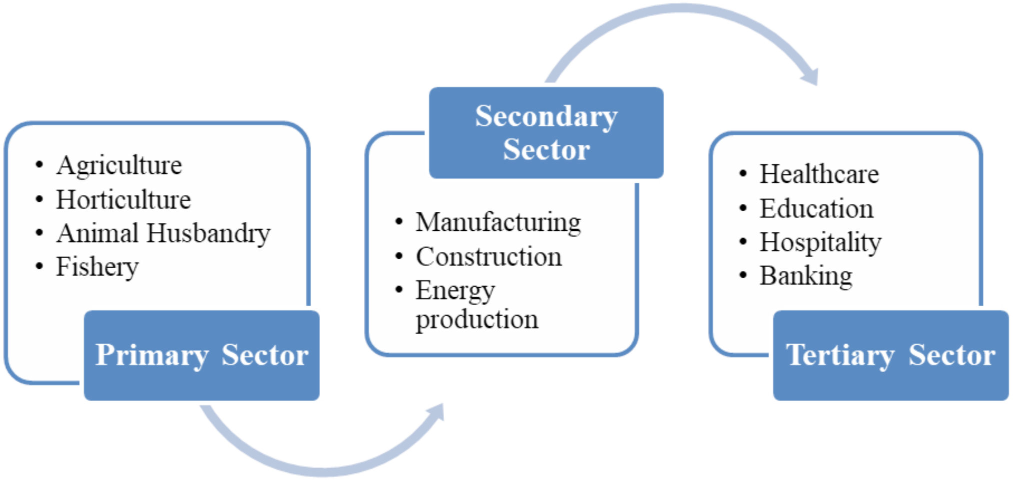
The activities which involve extraction and production of raw materials using natural resources are categorized under primary sector. It includes agriculture, forestry, fishery, mining and quarrying.

B. Secondary Sector

The secondary sector covers the activities like changing the natural products into other forms through ways of manufacturing, processing, etc. Here the product is not produced by nature, but rather are made through the process of manufacturing. This could be in a factory, a workshop or at home. Manufacturing of steel, weaving of cloth, using cotton fibre from the plant are examples of this activity.

C. Tertiary Sector/Service Sector

Tertiary activities provide support to the primary and secondary sectors through services. Activities under this sector do not produce goods themselves, however they provide an aid or a support for the production process. Transport, storage, trade, packaging, insurance, advertising, communication, banking are some examples of tertiary activities.



Importance of Primary Sector in Indian Economy

Primary sector helps in the development of nation in many ways like providing source of food, feed, fodder and fibre, income and livelihood support, employment generation, supplying raw material to industries, national income, international trade, etc.

2.2 INDIAN AGRICULTURE AT PRESENT SCENARIO

Agriculture is the foundation of livelihood, civilization, culture and heritage of India. It includes all aspects of crop production including horticulture, livestock management, fisheries, forestry, *etc*. Agriculture is defined as 'an art', science and business of producing crops and livestock for economic purposes. India being a developing country, most of the products that we consume in our daily life comes from agricultural activities like dairy, forestry, poultry and fishery.

Agriculture is the main source of livelihood to the rural Indian population, providing food, feed, fibre and supplying raw material to the industries. Since independence, India has made good progress in agriculture. The food grain production, which was merely 51 million tons (Mt) in 1950-51 increased over 6 times to be 316 Mt in 2022. Indian agriculture has made significant progress over the years. Today, agriculture is technology and knowledge-based.

- Earlier, farmers were using traditional farming practices for land preparation and weeding with the help of bullocks using *deshi* plough, irrigation by canal or surface water using labour, harvesting and threshing were done with the help of manual labour.
- Today farmers are using modern technologies at different stages of cropping from field preparation using tractor driven cultivator to harvesting of crops with the help of combine harvester, threshing with the help of thresher, efficient irrigation through micro-irrigation & sprinkler.

India has also become the largest producer of milk, pulses and jute and the second largest producer of rice, wheat, cotton, fruits and vegetables in the world. India is also one of the leading producers of spices, fish, poultry, livestock and plantation crops. Multiple other types of crops are also cultivated in our country. Latest modern technologies in agriculture include use of drone, satellite imaging and sensors, IoT-based sensor networks, weather forecasting, automated irrigation, application of data analytics and machine learning for decision making, etc.

INTEXT QUESTIONS 2.1

1. Which sector forms the base for the industrial and service sectors?

2. Which of the following is the component of agriculture?

   a. Livestock production   b. Fishery

   c. Poultry   d. All of the above

3. List out a few examples of the secondary and tertiary sectors.

2.3 ROLE OF AGRICULTURE IN INDIAN ECONOMY

Agricultural development is an integral part of the economic development of the nation. It contributes to development of economy through following ways:

1. Source of food, feed and fibre
2. Source of income and employment for the rural household
3. Supplying raw material to industries
4. Contribution in national income
5. Supplementing in international trade

2.4 SOURCE OF FOOD, FEED AND FIBRE

Food

The food we are consuming daily is coming from agriculture and agriculture related sectors like cereals, pulses, fruits, vegetables, dairy products and various packaged products. Following are the examples of few food producing plants

a. **Cereals:** Rice, wheat, maize, sorghum, bajra, ragi

b. **Pulses:** Gram, greengram, blackgram, redgram

c. **Oilseeds:** Sunflower, safflower, groundnut, sesame

d. **Fruits:** Mango, grapes, guava, banana

e. **Vegetables:** Potato, tomato, onion, cabbage, cauliflower, brinjal, spinach

f. **Spices:** Turmeric, chillies, ginger, garlic, black pepper, cardamom

g. **Medicinal & aromatic plants:** Tulsi, aloe vera, ashwagandha, fenugreek, lemon grass, mint, fennel

h. **Plantation crops:** Tea, coffee, coconut, arecanut, rubber

Notes

? DO YOU KNOW

Both cereals and pulses are together called food grains.

Table 2.1: Production of major food commodities in India (in million tonnes)

Commodity	**Year 1950-51**	**Year 2021-22**	**Times increase**
Food grains	51	317	6.2
Vegetables & fruits	25	333	13.3
Milk	17	210	12.4
Egg (billion)	1.8	122	67.8
Fish	0.8	14.2	17.8

Feed and Fodder

For rearing of cattle, farmers grow fodder crops. Fodder crops are those crops which grown primarily as feed for animals. Forage and fodder crops include berseem, sorghum, bajra, maize, napier grass, *etc*. Fodder may be of two types i.e. green and dry Examples of green fodders are berseem, sorghum, maize, bajra etc. and dry fodders are wheat straw, paddy straw, sorghum and bajra straw etc.

Various feed cakes are used as animal feed because they contain digestible fibre, minerals, and vitamins that are suitable for improving the health of cattle. Examples of feed cakes are groundnut cake, coconut cake, sunflower seeds cake, rapeseed cake, *etc*. Groundnut cake is one of the best protein supplements for livestock feeding and is extensively used.

By produce (straw) of most of the crops is used as fodder for animals like wheat straw, sorghum straw, maize straw, rice straw, *etc.* and they are also called dry fodder. Similarly, feeds for poultry and fisheries are also made from different agricultural produce.

Fibre

Fibre crops are the crops which are grown in the field for their fibres that are used to make cloth, ropes, paper, *etc*. Fibre crops are also known as natural fibres as they are

Notes

obtained directly or indirectly from nature or from different sources of plant and their products. Some examples of fibre crops are cotton, jute, hemp, coir, *etc*.

INTEXT QUESTIONS 2.2

1. Give three examples of cereal crops.
2. Write the name of three green fodder crops.
3. The crop grown for feeding of animals is called ....
4. Which of the following is dry fodder crop?

   a. Berseem   b. Wheat straw

   c. Napier grass   d. Cow pea
5. Which crop is used for making cloths?

   a. Rice   b. Maize

   c. Jute   d. cotton
6. Which feed cake is considered as best protein supplement for livestock?
7. Pick the odd one out

   a. Wheat, maize, gram, bajra

   b. Sunflower, groundnut, turmeric, sesame

   c. Grape, jute, guava, mango

2.5 SOURCE OF INCOME AND EMPLOYMENT

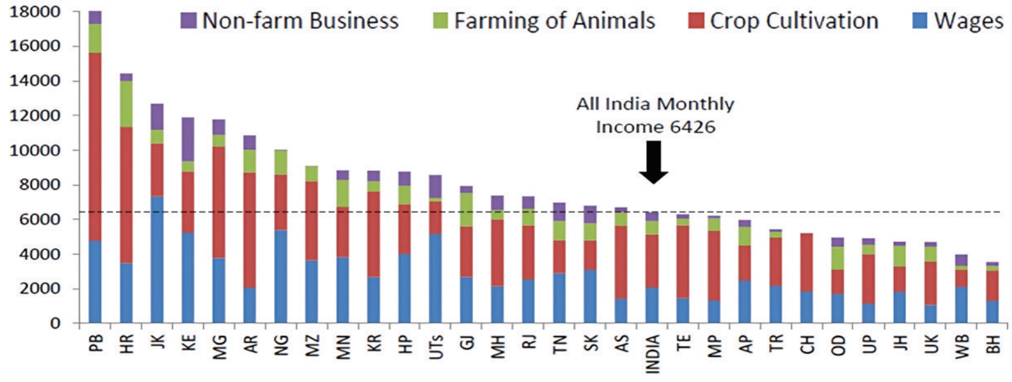
Besides securing food, feed and fibres, agriculture is also the main source of income and livelihood for the majority of the Indian population living in rural area. The allied activities of agriculture like livestock, forestry, fisheries, and poultry play an important role in the income of small and marginal farmers. If crop fails due to adverse climatic condition like excess rainfall, drought, insect and pest attack, these allied activities help the farmers in meeting their loss.

You can understand the importance of this sector on livelihood, employment generation by identifying the number of workers (farmers + labourers) engaged in agriculture. At

the time of independence, around 72 % of the Indian population was engaged in agriculture and agriculture related activities. Even today about 55 % of the Indian population is engaged in agriculture (Economic Survey, 2022). Although people are migrating from rural area to urban areas, still this sector is the largest employer of the workforce in India.

Notes

- Rearing of cattle is considered as one of the best source to augment the household income by selling milk and milk products to the neighbours or villagers on daily basis.
- Modern agriculture is technology based. Through learning of new technologies, people can professionally engage with various sectors of agriculture for earning. There are lots of employment opportunities in various field businesses like agri-startup, warehousing, cold storage, processing industry, infrastructure development, marketing, Farmers Producer Organization (FPOs), *etc*.



PB – Punjab, **HR** – Haryana, **JK** – Jammu & Kashmir, **KE** – Kerala, **MG**- Meghalaya, **AR** – Arunachal Pradesh, **NG** – Nagaland, **MZ** – Mizoram, **MN** – Manipur, **KR** – Karnataka, **HP** – Himachal Pradesh, **UT** – Union territory, **GJ** – Gujarat, **MH** – Maharashtra, **RJ** – Rajasthan, **TN** – Tamil Nadu, **SK** – Sikkim, **AS** - Assam, **TE** –Telengana, **MP** –Madhya Pradesh, **AP** – Andhra Pradesh, **TR** – Tripura, **CH** – Chhattisgarh, **OD** - Odisha, **UP** – Uttar Pradesh, **JH** – Jharkhand, **UK** – Uttarakhand, **WB** – West Bengal, **BH** - Bihar

Fig. 2.1: State-wise monthly income of the farmers in different sources (Source: Report on Doubling Farmers Income (2017))

The fig 2.1 shows the average monthly income of farmers for various states of India. Here you can identify that monthly income of a farmer is not same in every state. In state like Punjab, it is very high while in Bihar, it is very low. You can observe that the all India monthly average income of farmer is Rs. 6426/-.

Notes

ACTIVITY 2.1

You have seen that monthly income of farmer varies from state to state. Why does it happen? Think about it and discuss with your parents.

....

....

....

Table 2.2: Total number of workers and share of cultivators and agriculture labourers in India

Year	Total Workers (Million)	Agricultural Workers (Million)			Share in total workers (%)		
		No of Cultivators	No of Agricultural Labourers	Total	% Cultivators	% Agricultural Labours	% Total agricultural workers
1951	139.5	69.9	27.3	97.2	50.11	19.57	69.68
1961	188.7	99.6	31.5	131.1	52.78	16.69	69.48
1971	180.4	78.2	47.5	125.7	43.35	26.33	69.68
1981	244.6	92.5	55.5	148.0	37.82	22.69	60.51
1991	314.1	110.7	74.6	185.3	35.24	23.75	58.99
2001	402.2	127.3	106.8	234.1	31.65	26.55	58.20
2011	481.9	118.8	144.3	263.1	24.65	29.94	54.60

Source: Report on Doubling Farmers Income (2017)

In the table 2.2, you can observe that the number of farmers (cultivators) was increasing till the year 2001, however, since then, it has declined. In case of agricultural labourers, their numbers have grown from 2001 to 2011; it increased from 106.8 million to 144.3 million. The percentage of agricultural labourers to total workers in the economy has been decreasing. This indicates that some number of the population is shifting out from agriculture to other sectors. This shifting work force may be going for job, self-employment in industries or for higher studies.

INTEXT QUESTIONS 2.3

1. Which occupation is the major source of employment for Indian population?
2. The average monthly income of the farmers in India is ....
3. At present how much percentage of Indian population is engaged in agriculture and agriculture related activities?

ACTIVITY 2.2

Visit your neighbourhood and identify the crops grown by them. Categorize those crops under different crop groups, like cereals, pulses, fruits, vegetables, fodder etc.

....

....

....

Notes

2.6 SUPPLYING RAW MATERIAL TO INDUSTRIES

Agriculture is the base for other sectors of the economy i.e. secondary and tertiary sector. In India, agriculture is the major source of raw materials for various industries. Agriculture and industry are interrelated to each other for their development. The industries which are based on agricultural production are called Agro-based industries. Few examples of these are food industry, sugar industry, textile industry, edible oil, plantation industries (viz. tea, coffee, rubber), and cottage industries.

- Children's favourite jam, jelly, candy, murabba, sauce, ketchup, pickles, *etc*. all are processed products made by processing of various agricultural or livestock product.
- Variety of sweets and dairy products like chocolates, ice cream, paneer, etc. are made from milk and milk products.
- In winter season, we all require woollen cloths. The wool is harvested from sheep.
- Meat industry has been growing very fast since last two decades.

- Agriculture also depends on various other industries like fertilizer, agro-chemicals, farm machineries, irrigation equipment, credit from financial institution, etc.

Notes

ACTIVITY 2.3

Make a list of food items at your home and categorize into fresh agricultural commodities, processed commodities, or value added commodities.

(Note: Fresh commodities are those which are in the same form as it might be harvested from the field. Processed commodities are those whose form have been changed without adding any other material. Value added commodities may be those which are manufactured by processing and mixing of more than two commodities)

....

....

....

2.7 IMPORTANCE OF AGRICULTURE IN INTERNATIONAL TRADE

India is one of the largest agricultural product exporters in the world. It helps in earning foreign exchange and providing gainful employment to large population. Agricultural export constitutes 12.42 per cent of the total country's exports. During 2021-22, the country recorded US $ 49.6 billion in total agriculture exports.

- India's agriculture sector primarily exports agricultural produce, marine products, plantation, and textile & allied products.
- Marine products, sugar, spices, meat, and raw cotton are major exported products.
- Rice (Basmati and non-Basmati) is the largest exported agricultural product from India.

The largest importers of India's agricultural products are USA, China, Bangladesh, UAE, Indonesia, Vietnam, Saudi Arabia, Iran, Nepal and Malaysia. Organisations like the Agriculture and Processed Food Products Export Development Authority (APEDA), the Marine Products Export Development Authority (MPEDA), commodity boards like the Coffee Board, Rubber Board, Spices Board, *etc*., are actively involved to promote the export of various agricultural and allied commodities.

Notes

Table 2.3: Export of major agricultural commodity from India from 2017-18 to 2021-22

Commodities (Quantity in '000' tonnes)	**Year**				
	2017-18	**2018-19**	**2019-20**	**2020-21**	**2021-22**
Non-Basmati Rice	8,633	7,534	5,036	13,087	17,260
Wheat	229	183	217	2,086	7,234
Basmati Rice	4,051	4,415	4,454	4,631	3,947
Cashew	90	78	84	70	75
Fresh Vegetables	2,296	2,915	1,927	2,326	2,384
Fresh fruits	657	736	819	956	1,164
Buffalo Meat	1,348	1,233	1,152	1,085	1,176

(Source: APEDA, 2022)

Moreover, India also imports some agricultural products. Indonesia is the largest agri-exporter to India, followed by Malaysia, Argentina, Ukraine, and USA. Major imported agricultural products are

Vegetable oil > Pulse > Spice > Processed cashew

INTEXT QUESTIONS 2.4

1. Give two examples of agro based industries.
2. The major commodity exported from India is
   a. Vegetable oil
   b. Basmati rice
   c. Processed cashew
   d. Rubber
3. India imports agricultural products majorly from Indonesia (True/False).

Notes

2.8 SHARE IN NATIONAL INCOME

National income means total amount of money earned by people within a country in a year. Economic activities like crop cultivation, forestry, fisheries, agro based industries, employment, exports, imports, etc. contribute to the total national income.

At the time of independence, agriculture was the main source of national income and contributed nearly 50% to India's national income. However, with rapid growth of other sectors (secondary or tertiary), the share of agriculture in the Indian economy has decreased. Still, agriculture continues to be major the source of livelihood for the majority of Indian population. But it is also important to note that the growth of other sectors depends on the performance of agriculture sector. Because of this reason, agriculture continues to be the dominant sector in Indian economy. Therefore, this sector remains largest employer of workforce in India which accounted for about 15% to the overall Gross Domestic Product (GDP) of India during 2022-23 (Economic Survey, 2023).

Table 2.4: Share of different sectors in Indian economy (as percentage of GDP)

Sectors	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**2010s**	**2022-23**
Agriculture & allied activities	43.7	40.6	34.6	28.7	22.5	15.2	15.13
Industry	15.8	16.9	19.0	20.6	20.7	20.9	30.67
Services	40.5	42.5	46.3	50.7	56.8	63.9	54.20

In table 2.4, we can see the share of different sectors of economy (e.g. agriculture, industry and services) from 1960s in terms of their contribution in gross domestic product (GDP). It is noticed that contribution of agriculture was 43.7% in 1960s which was gradually reduced to 15.2% in 2010. In the same period, the contribution of industry and service sector has increased from 15.8 to 20.9% and 40.5% to 63.9% respectively. This indicates higher growth in industry and service sector than agriculture sector at present time. You will learn the reason for this uneven growth in subsequent chapters.

Notes

INTEXT QUESTIONS 2.5

1. Agricultural activities that contribute to national income are ...., ...
   & ....

2. How much is the agriculture sector currently contributing to national income?

ACTIVITY 2.4

Identify the different sectors of economy producing the following products. Provide tick marks (√) against right answer.

Products	**Sectors of economy**		
	Primary	**Secondary**	**Tertiary**
Chips			
Wheat			
Paddy			
Ice cream			
Steel			
Bricks			
Mobile services			
Pop corn			
Chappati (bread)			
Ladies finger/Bhendi			
Pea			
Boiled rice			

WHAT YOU HAVE LEARNT

- Importance of agriculture lies in providing food and employment generation for majority of Indians.
- Different types of crops include field crops, cereals, pulses, horticultural crops, plantation crops, *etc*.
- An economy of a country can be divided in primary, secondary and tertiary sectors. Agriculture is the primary sector of Indian economy. Agriculture is the base for industrial and service sector.
- Today's agriculture is technology based. Improved technologies for agriculture are superior variety of crops, harvesting with the help of harvester, threshing with the help of thresher, agricultural drone, satellite photography and sensors, IoT-based sensor networks, weather forecasting, automated irrigation, *etc*.
- Agriculture is the largest employment providing sector in India. At present about 55% of Indian population is engaged in agriculture and agriculture related activities. There are lots of employment opportunities in agriculture sector like Startup, warehousing, cold storage, processing industry, infrastructure development, marketing, Farmers Producer Organization (FPOs), *etc*.
- Agriculture and allied sector contribute about 15% to the GDP of India.
- Agriculture supplies raw materials to the most of the agro based industries.
- Agriculture plays an important role in international trade. It helps to earn huge money by exporting agricultural products in foreign countries.

TERMINAL QUESTIONS

1. Give definition of agriculture.
2. Which are the three sectors of Indian Economy?
3. How agriculture is the basic source for food, feed and fibre? Discuss in detail.
4. Why does agriculture continue to remain important for Indian economy? Explain.
5. Agriculture is the major source of raw materials to various industries. Why?

6. 'Agriculture plays an important role in international trade'. Justify the statement.
7. Discuss about secondary and tertiary economic activities.

ANSWERS TO INTEXT QUESTIONS

2.1

1. Agriculture
2. All of the above (option d)
3. Secondary – manufacturing and construction

   Tertiary – education and banking

2.2

1. Rice, wheat and maize
2. Berseem, maize and bajra
3. Fodder crop
4. Wheat straw (option b)
5. Cotton (option d)
6. Groundnut oilcake
7. a) Gram (Explanation: Gram is a pulse crop, others are cereal crop)

   b) Turmeric (Explanation: Turmeric is a spice crop, others are oilseed crop)

   c) Jute (Explanation: Jute is a fibre crop, others are fruit crop)

2.3

1. Agriculture and allied activities
2. Rs. 6426/-
3. 55%

Notes

2.4

1. Sugar and textile industry
2. Basmati rice (option b)
3. True

2.5

1. Crop cultivation, forestry, fisheries
2. 18.6%

GLOSSARY

Cold Storage: A cold storage is a large refrigerated room or building designed for storage of goods in an environment below the outdoor temperature.

Exports: Exports are goods and services that are produced in one country and sold to buyers in another.

GDP (Gross Domestic Product): A country's Gross Domestic Product or GDP is the total monetary or market value of all the goods and services produced within the territory of the country during a specified period of time.

GVA (Gross Value Added): Gross Value Added (GVA) is the measure of the total value of goods and services produced in an economy (area, region or country) and the amount of value added to a product. While the GDP measures the total value of products and services that the country manufactures or delivers, the GVA measures the value added to the product in order to enhance its worth.

Imports: Imports are opposite to the exports. That means purchasing the commodities from other countries.

Start-up: A start-up is any business entity that is in the initial stages of business, but may have potential to scale up.

Warehouse: A warehouse is a large building where raw materials or manufactured goods can have stored until they are exported to other countries or distributed to shops.

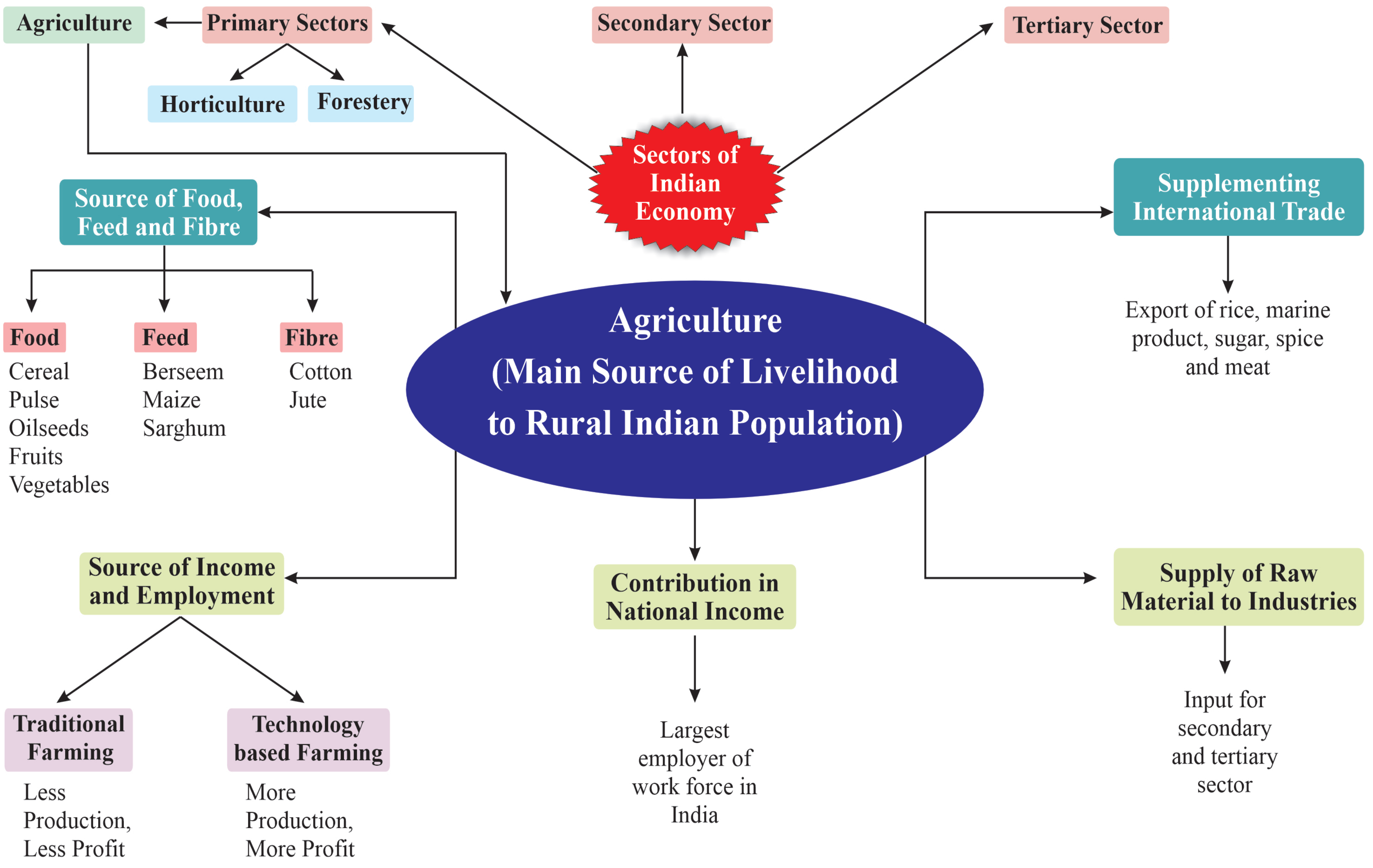
SUGGESTED READING

1. *Hand Book of Agriculture*, Published by Indian Council of Agricultural Research (ICAR), New Delhi.

2. Singh, A., Sandhu, A. N. and Singh, J. (2014). *Fundamentals of Agricultural Economics*, Himalaya Publishing House, New Delhi.

Notes

WHAT YOU HAVE LEARNT



3

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CHARACTERISTICS OF INDIAN AGRICULTURE

India has a variety of soil, topography and climate. There are a very few countries in the world which have such a wide range of agro-climatic conditions, due to which different types of crops and livestock can be grown. Indian agriculture comprises production of crops, livestock- milk and meat, fisheries, poultry, and several other rural enterprises like honey production, wool production, etc. Therefore, agriculture in India is the largest private enterprise providing income and employment to millions of households directly or indirectly. But lack of awareness and access to modern technology, lack of market access, lack of assured irrigation, poor risk coverage, etc. make Indian agriculture highly vulnerable to the vagaries of nature as well as market forces. Still crop production remains the mainstay for the rural households.

LEARNING OUTCOMES

After studying this lesson, the learner:

- defines the concept of farm and farm size;
- identifies the land use pattern in India;
- recognizes the different agro-ecological zones of India;
- explains the various systems of farming practiced in India; and
- analyzes the importance of allied sectors in agriculture.

Notes

3.1 FARM AND FARM SIZE

Usually, a **farm** is a piece of land, where crops and livestock production are taken up by a household or a farmer. Thus, it is an area of land that is primarily devoted to agricultural purposes with the main objective of producing food and other crops.

A **farmer** is a person who owns the land and/or operates an agricultural enterprise, either commercially or to sustain his family. While **agricultural labour** is basically a semi-skilled or unskilled person employed to a farm in connection with cultivating the soil or performing any farm operations, including raising, feeding, caring for, and managing livestock, bees, poultry, and fur-bearing animals.

The size of a farm is determined by the operational holding of a household. An **operational holding** is defined as all land which is used wholly or partly for agricultural production by one household, regardless of the legal ownership or location.

Table 3.1: Classification of farmer according to farm size/ operational holding

Type of farmer	Area of farm
1. Marginal	Below 1 ha
2. Small	Between 1 to 2 ha
3. Semi-medium	Between 2 to 4 ha
4. Medium	Between 4 to 10 ha
5. Large	10 ha and above

Note: 1 hectare (ha) = 2.47 acres or 10,000 m^2

In India, smallholders refer to marginal and small farmers. They constitute 86.1% of total farms of our country. The all India average land holding size is 1.08 hectares (ha). Many farmers in India are landless as well, who don't have their own land, but operate on land taken on lease from landholders. Such farmers are also known as **tenant farmers**.

Table 3.2: Number of holdings, operated area and average size of holdings of different size holdings

		Agriculture census 2015-16				
Sr. No.	**Size Group**	**Number of Holdings (in '000)**	**Area Operated (in '000 ha.)**	**Percentage of holdings to total holdings**	**Percentage of area operated to total area**	**Average operated area per Holding (ha.)**
1	Marginal	1,00,251	37,923	68.45	24.03	0.38
2	Small	25,809	36,151	17.62	22.91	1.40
3	Semi-Medium	13,993	37,619	9.55	23.84	2.69
4	Medium	5,561	31,810	3.80	20.16	5.72
5	Large	838	14,314	0.57	9.07	17.07
	All Sizes	1,46,454	1,57,817	100.00	100.00	1.08

Source: Agricultural Census (2015-16)

Notes

3.2 LAND USE PATTERN IN INDIA

The country has large area of land under crop cultivation. Currently, about 60 per cent of cultivated lands are rainfed, where farmers mainly depend upon seasonal rainfall for crop cultivation. Further, majority of rural households still depend on agriculture for their livelihood. Among them, most of farmers are small and marginal (85%). These small farmers have very small land area for cultivation. Therefore, they are producing small quantities of food mainly for their household consumption and very little are left for selling in market. The country has total geographical area of 328.73 million hectares (Mha). But only 93% of total geographical area is available officially as reports from some of the difficult regions are not completed yet (Land use statistics 2018-19).

Land resources are used for the following purposes:

Notes

1. Forests

It is a large area mostly covered with trees and vegetation. It is the source of clean air and water. Therefore, maintaining a forest area is highly essential for survival of human. Ideally, a country should maintain 33% of its geographical area under forest for maintenance of the ecological balance while India has only 24.6% area occupied by forest. It is observed that the forest area has increased over the years, although it is far lower than the desired proportion.

2. Land not available for Cultivation

a. Barren and waste land: It includes desert, snow covered area or steep mountainous area.

b. Land put to non-agricultural uses e.g. roads, buildings, factories, etc.

3. Other Uncultivated Land (excluding fallow land)

a. Permanent pastures and grazing land

b. Land under miscellaneous tree crops and mangroves

4. Fallow Lands

a. Current fallow (left uncultivated for one or less than one year)

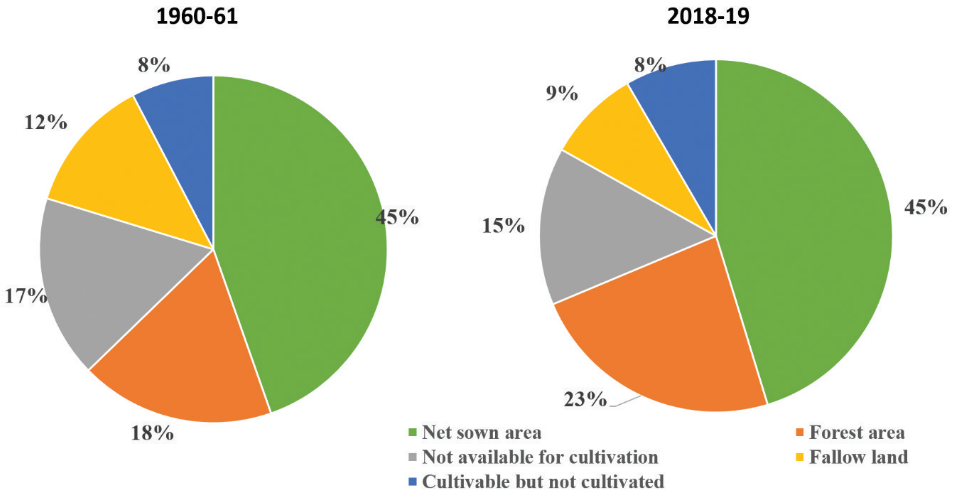
b. Other than current fallow (left uncultivated for the past 1 to 5 agricultural years)

5. Net Sown Area

It is the total land area on which crops are sown. If an area is cultivated multiple times in year, it is still counted once only. For example, suppose a farmer has 2 ha land where he grows rice in *kharif* season and wheat in *rabi* season. Therefore, his net sown area is 2 ha, while gross cropped area will be (2+2) = 4 ha.

In India, 139.35 million hectares (Mha) is estimated as net sown area (NSA). In about 58 Mha areas, crops are grown more than once in a year, which makes gross cropped area (GCA) to 197.3 Mha.

The area of cultivated land where irrigation is provided to grow crops is called net irrigated area. If more than one crop is cultivated in a year, counting all the irrigated areas for all season and all crops will be gross irrigated area. India has 71.55 Mha as net irrigated area and 102.67 Mha as gross irrigated area during



2018-19. Out of total irrigated area, 35 per cent is irrigated by tube-wells, while 16 per cent by canal. The land use pattern varies from one state to another.

Fig 3.1: *Land use pattern of India in 1960-61 and 2018-19*

Source: Ministry of Agriculture & Farmers' Welfare, Govt. of India, 2021

Measurement Table

1 hectare	=	10,000 m^2
1 hectare	=	2.471 acres
1 acre	=	4046.86 m^2
1 acre	=	4840 sq. yard
1 tonne	=	1,000 kg
1 million	=	10 lakhs
1 billion	=	1000 million

INTEXT QUESTIONS 3.1

1. Total net sown area of India is ....

2. Which category of farmers has maximum operational land holding in India?

3. Land size of marginal farmer

   a. 1 to 2 ha   b. 2 to 4 ha

   c. <1 ha   d. > 10 ha

4. India has a geographical area of

   a. 329.7 M ha   b. 328.7 M ha

   c. 325.7 M ha   d. 324.7 M ha

3.3 CHALLENGES OF INDIAN AGRICULTURE

Indian agriculture faces several challenges that impact its productivity, sustainability, and overall growth. Some of the key challenges include:

1) **Lack of Crop Diversification:** The agriculture sector is susceptible to price swings and market uncertainty due to its reliance on a small number of primary crops (e.g. rice, wheat, maize, sugarcane, etc). Promoting crop diversification can help in sustainable agricultural practices and risk reduction.

2) **Outdated Agricultural Practices:** Traditional agricultural methods are still used by a large number of Indian farmers, which results in low yields and inefficient farms. Sustainable agriculture depends on the use of contemporary equipment, technology, and scientific agricultural practices.

3) **Small and Fragmented Landholdings:** As a result of population increase and the dissolution of the joint family structure, agricultural land has been continuously divided into fewer and smaller parcels. Such tiny landholdings restrict farmer's capacity to use modern farming methods and technology. A fragmented land base frequently prevents large scale adoption of agricultural machinery and lowers total production.

4) **Dependency on Rainfall:** India's agriculture is mostly dependent on the monsoon. Distribution of rainfall is not the same throughout the country. Thus food grain output varies from place to place. Generally, after a year of abundant crop production there follows typically a year of severe deficit.

5) **Lack of Access to Credit and Market:** It is often difficult for small and marginal farmers to get insurance and loans. This restricts their capacity to invest in cutting-edge farming equipment, technology, and inputs. Farmers frequently encounter difficulties reaching markets as a result of poor infrastructure, problems

with transportation, and intermediaries. Furthermore, changes in the price of food might have an effect on farmers' earnings.

6) **Degradation of Soil Health:** Excessive use of chemical fertilizers and pesticides, coupled with poor soil management practices, contribute to soil health deterioration, affecting long-term agricultural sustainability.

However, recent developments addressing some of these issues like diversification of agriculture towards fruits and vegetables, collectivization of farming activities, market reforms, credit and insurance policies, digital agriculture, various government schemes, etc. are helping the farmers in getting better income from agriculture.

3.3 AGRO CLIMATIC ZONES OF INDIA

Different crops need different types of climate for their growth. Even soil conditions like structure, depth, topography or moisture holding capacity can also significantly affect crop germination and growth. Hence season of planting; production and distribution of crops generally vary from region to region. Thus suitability of crops in different areas is controlled to a large extent by climate and soil. Classification of country into several agro-climatic zones was done with the primary objective of helping the farmers in selection of suitable crops according to the region. It will increase the farmer's income and reduce the regional inequalities in agricultural development by optimizing the agricultural production through judicious use of the available irrigation water. The Planning Commission of India divided total geographical area of country into 15 agro-climatic regions based on topography, annual rainfall, and temperature. These are:

1. **Zone 1 - Western Himalayan Region:** Jammu and Kashmir, Uttar Pradesh
2. **Zone 2 - Eastern Himalayan Region:** Assam, Sikkim, West Bengal and all North-Eastern states
3. **Zone 3 - Lower Gangetic Plain Region:** West Bengal
4. **Zone4 - Middle Gangetic Plain Region:** Uttar Pradesh, Bihar
5. **Zone 5 - Upper Gangetic Plain Region:** Uttar Pradesh
6. **Zone 6 - Trans-Gangetic Plain Region:** Punjab, Haryana, Delhi and Rajasthan
7. **Zone 7 - Eastern Plateau and Hill Region:** Maharashtra, Uttar Pradesh, Orissa and West Bengal

Notes

8. **Zone 8 - Central Plateau and Hill Region:** MP, Rajasthan, Uttar Pradesh

9. **Zone 9 - Western Plateau and Hill Region:** Maharashtra, Madhya Pradesh and Rajasthan

10. **Zone 10 - Southern Plateau and Hill Region:** Andhra Pradesh, Karnataka, Tamil Nadu

11. **Zone 11 - East Coast Plain and Hill Region:** Orissa, Andhra Pradesh, Tamil Nadu and Pondicherry

12. **Zone 12 - West Coast Plain and Ghat Region:** Tamil Nadu, Kerala, Goa, Karnataka, Maharashtra

13. **Zone 13 - Gujarat Plain and Hill Region**: Gujarat

14. **Zone 14 - Western Dry Region:** Rajasthan

15. **Zone 15 - The Islands Region:** Andaman and Nicobar, Lakshadweep

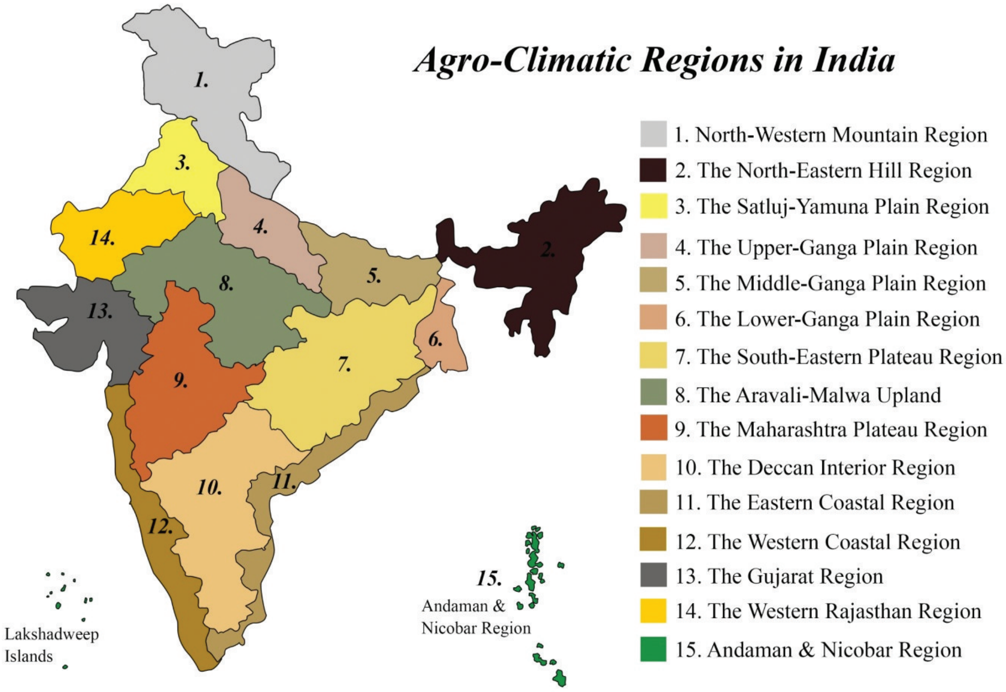


Fig. 3.2: Agro-climatic zones of India

3.4 DIFFERENT SOIL TYPES OF INDIA

India has a variety of soils due to its diverse geographical and climatic conditions. This diversity considerably affects agriculture, land use planning, and environmental

management. In India, the Indian Council of Agricultural Research (ICAR) has classified soils into 8 categories based on **colour and composition of the soils**. Figure 3.3 shows the distribution of various types of soil all over India.

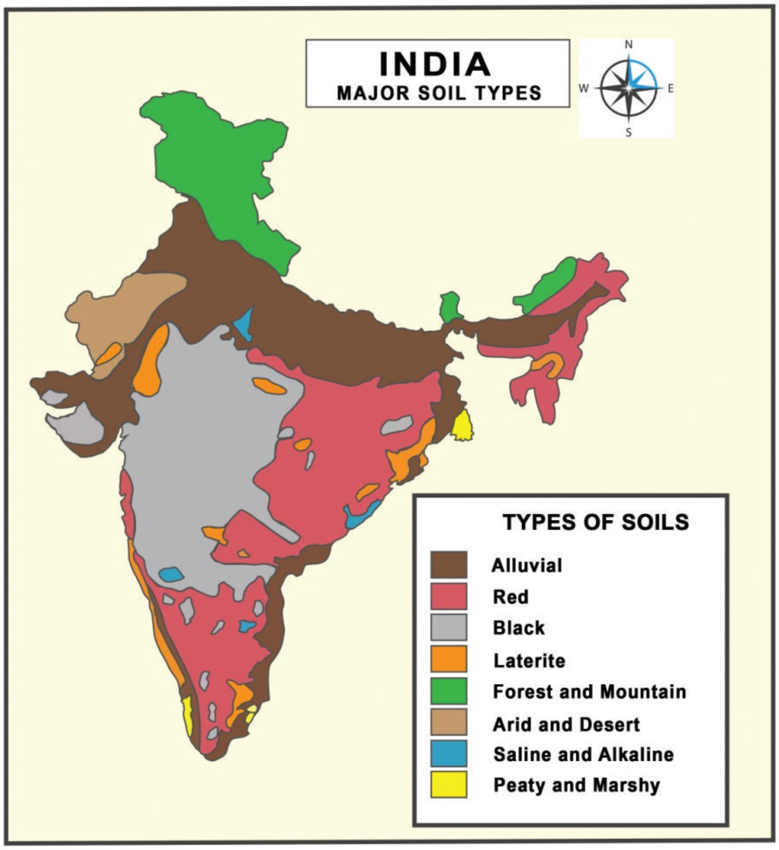


Fig 3.3: *Distribution of major soils of India*

Notes

A. **Alluvial Soil:** This soil type covers the largest area in the country and occupies 113 Mha in the Indo-Gangetic Plain, Brahmaputra Valley and Coastal area. The most recent young alluvial soils are called "*Khadar*" and old alluvial soils are called "*Bhangar*". Alluvial soils are considered to be the most fertile soils in India. The alluvial soil consists of various proportions of sand, silt and clay. Alluvial soils contain adequate prportion of potash, phosphorus and calcium, which are ideal for crop growth.

B. **Red Soil:** Red soils are occupying about 85.7 Mha in the states of Telangana, Tamil Nadu, Karnataka, *etc*. These are well drained soils found in semi-arid to warm humid tropical climates. These soils are generally developed from granite and metamorphic rocks like gneisses and schists. This type of soil is found in low rainfall regions.

Notes

C. **Black soil:** These are very dark, clay dominated soils. Black soils are also known as Black Cotton Soil or "*regur* soil" (in Central India) and "*bhal*" (in Gujarat). These soils occupy about 55 Mha, mostly found in Maharashtra, Madhya Pradesh and Gujarat states. Black colour of soil is due to presence of clay humus complexes. They are well known for their excellent water holding capacity. In addition, they are rich in calcium, magnesium, potash and lime, but generally poor in phosphate content. These soils develop deep cracks during hot weather, while becomes sticky when wet.

D. **Laterite or lateritic soil:** These soils are formed by laterization (alkaline hydrolysis) process, in tropical and subtropical climate with alternate wet and dry season. This soil is the result of intense leaching due to heavy rain. It is acidic ($pH<6.0$) in nature, generally deficient in plant nutrients. It is found mostly in southern states, Western Ghats region of Maharashtra, Odisha, some parts of West Bengal and north-east regions. These soils are red in colour, have high clay content, deeply weathered and very deep. This soil is useful for tea and coffee cultivation. In Andhra Pradesh, Odisha and Kerala, cashew nut is cultivated in this soil.

E. **Arid soil:** Arid soil is red and brown in colour and sandy in texture. It is alkaline in nature. This soil type is found mainly in parts of Western Rajasthan, Haryana, Punjab and extends up to the Rann of Kutch in Gujarat. Due to high calcium content, the bottom horizon of the soil is full of '*Kankar*' (pebbles), which restricts the infiltration of water through the soil. Due to dry climate and high temperature, it contains a very low percentage of organic matter.

F. **Forest and mountain soil:** These soils are found in the hilly mountainous areas where sufficient forests are available. These are loamy and silty in valley sides and coarse grained on the upper slopes.

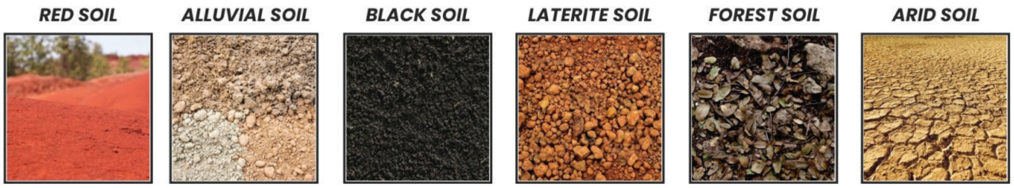


Fig. 3.4: Major soil types found in India

Notes

Table 3.3: The details of potential and problems of major soils of India

Sl. No.	Soil	Potential	Problems
1.	Alluvial soils	One of the best soil and used for growing most agricultural crops and spread in Indo-Gangetic plains (IGP), Brahmaputra valley and coastal area	Rich in plant nutrient but deficient in organic carbon, nitrogen (N) & phosphorus (P). Prone to salinization due to faulty irrigation and bad drainage.
2.	Black soils	Inherently fertile and used for growing cotton, citrus, millets, sorghum, soybean, pigeonpea, wheat and sugarcane. Spread in Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Chhattisgarh and some parts of Karnataka and Tamil Nadu.	Narrow workable moisture, poor drainage, low infiltration, calcareousness induces micronutrient deficiency. Inherently fertile but problem in workability and development of subsoil sodicity in some pockets.
3.	Red soils	Produces good yield under proper management of agricultural, horticultural & plantation crops. Spread in Tamil Nadu, Karnataka, Goa, Maharashtra, Madhya Pradesh, eastern and north-eastern regions of Bihar, Jharkhand, West Bengal, Assam and Uttar Pradesh.	Prone to surface crusting and hardening, poor natural fertility, low CEC (cation exchange capacity), P-fixation Poor in organic carbon, nitrogen (N) & phosphorus (P) content. Respond well to potassium management

Notes

Sl. No.	Soil	Potential	Problems
4.	Laterite and lateritic soils	Formed by laterization process found in Malabar hills of Kerala. Spread in Maharashtra, Orissa, some parts of West Bengal and north-east regions.	Deficient in almost all nutrients but can be managed well if suitable management practices are adopted. Liming is essential for better crop production.
5.	Salt-affected soils	These soil contain excess of neutral soluble salt (especially chloride and sulphate salt of sodium, calcium and magnesium). Mostly found near coastal areas. Fertile soils developed salinity and sodicity due to faulty irrigation. Cultivated for salt-tolerant crops like, rice, wheat, sugarcane, barley, oats, cotton, etc. and a variety of grasses like Karnal grass, Bermuda grass.	Leaching of salts with good quality irrigation water along with adequate drainage network is essential for of removal of leached water. Sodic soils are reclaimed by gypsum application. In case of calcareous sodic soil, pyrites used for reclamation.
6.	Desert soil	These soils occupy the western part of Rajasthan, Gujarat, Haryana and Punjab. Cold arid soil found in in Leh, Ladakh. These are light soils with less than 10% clay.	Light soil, poor in nutrient and water holding capacity
7.	Forest and hill soils	These soils are developed under forest canopy. Spread in Himachal Pradesh, Jammu and Kashmir, Uttarakhand, Sikkim, Madhya Pradesh, Kerala, NE regions and Andaman & Nicobar	Bench terracing and soil conservation practices are required for cultivation

Notes

Sl. No.	Soil	Potential	Problems
		Islands. Soils of cool climates, under coniferous forests of Himalaya are strongly acidic, high in organic carbon, moderately high in clay.	
8.	Peat and Marshy Soils	Developed under humid climate and in localized pockets of Kerala and eastern region of tidal swamps. High amount of organic matter with presence of pyrites (FeS_2). Generally, submerged (reduced) but sulphuric acid is formed when oxidized. Rich in organic matter. Rice cultivation is generally practiced.	Soil becomes extremely acidic after drainage.

INTEXT QUESTIONS 3.2

1. India has been divided into how many Agro-Climatic Zones?

   a. 17   b. 15

   c. 18   d. 16

2. Alluvial soil also known as

   a. Regur   b. Khaddar

   c. Bhangar   d. Both b and c

3. Which type of soil is more suitable for cotton crop?

4. '*Kankar*' is found in .... soil.

3.5 DIFFERENT FARMING SYSTEMS IN INDIA

A farming system is a mix of farm enterprises such as crops, livestock, aquaculture, agro-forestry and fruit crops to which farm family allocates its resources in order to

efficiently manage the existing environment for the attainment of the family goal. However, Food and Agriculture Organization (FAO) defined farming system as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate.

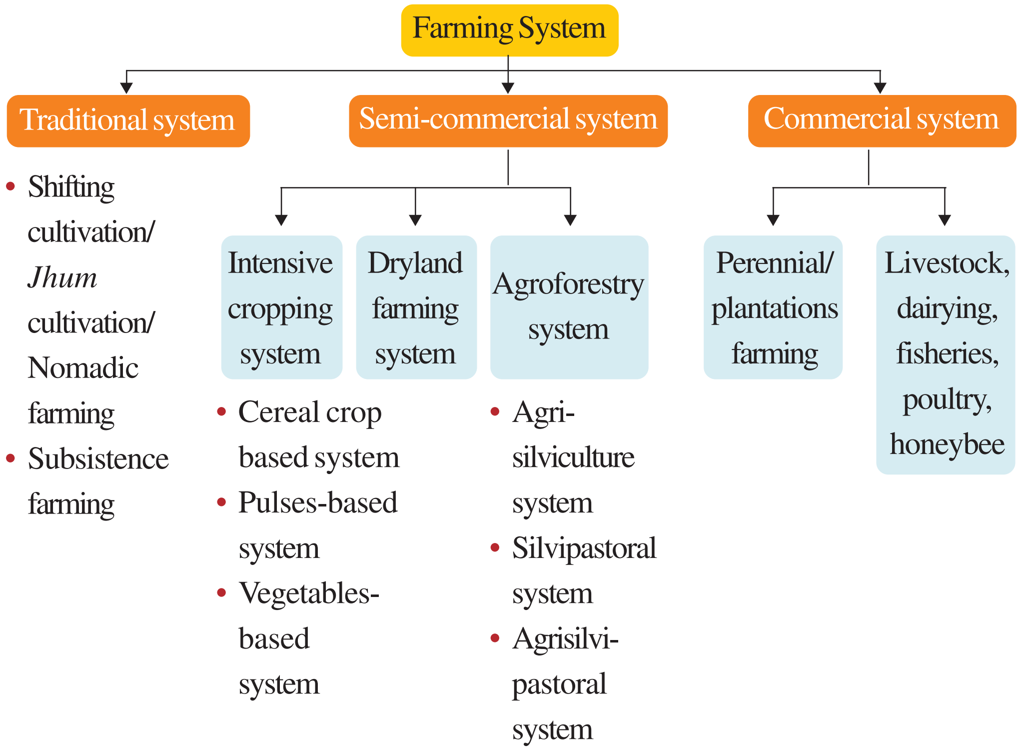


Fig. 3.5: Different farming systems of India

Shifting/ Nomadic Farming

In this type of farming system, forest land is cleared by felling trees and burning the bushes. Once the land is cleared, crops are grown for two to three years and then the land is abandoned as the fertility of the soil decreases. The farmers then move to new areas and the process is repeated. Paddy, maize, millets and vegetables are the crops commonly grown in this type of farming. This is practiced mostly in North East Region of India.

Subsistence Farming

Under this, farmer household produces cereals mainly for household consumption and only residuals are sold in the local market. It is characterized by small and scattered land holdings. They use sub-optimal quantity of fertilizers and local variety of seeds. Cereals like wheat, rice, millets, pulses, vegetables, etc. are mainly grown. Some farmers also rear small number of livestock like cow, buffalo, bullocks, sheep or goat.

Intensive Cropping System

Intensive farming is currently practiced in most parts of the country. Farmers try to grow 2-3 crops in a year from the same piece of land to maximize the production and income by intensive use of improved varieties of seeds, chemical fertilizers, irrigation, and farm mechanization. This is also known as Industrial agriculture. This farming system is possible only in those areas where irrigation facility is available. India could achieve food security with the intensive farming of rice and wheat in large parts of Indo-Gangetic plain region.

Dryland Farming System

Dryland farming is a practice of growing crops without irrigation in areas where average annual rainfall is less than 1150 mm. In this region, crops are grown on available moisture only, as very limited irrigation water may be available. In some areas where rainfall is little high (> 1150 mm), rainfed farming is also prevalent. In these areas, mostly single crop or intercrops are grown in a year. Dryland farming is also subject to high variability in areas sown and crop yield.

Agro-forestry Farming System

Agroforestry is the integration of woody perennials, such as trees and shrubs, with crops, livestock, or fish production. It may be of different types. In case of agro-silviculture, trees and agriculture crops are grown together in same lands at the same time. In a silvipastoral system, trees and shrubs are grown with the field crops, so as to produce fodder for livestock. This system is needed in dry area to meet the fodder demand throughout the year. Similarly, in case of agri-silvi-pastoral system, tree crops + grain crops + animals are raised together. Forest tree crops for fodder like Subabul, Babool, Khejri etc. are taken with intercropping of grasses like stylo, berssem, etc. for fodder purpose as well as the food grain crops like maize, rice, *jowar*, etc. in between the strips of forest tree species.

Plantation Agriculture

It is mainly perennial crops oriented farming system, which are grown on large areas, like fruit orchard, tea, coffee, rubber, arecanut, coconut, palm oil, etc. It requires good managerial ability, technical knowledge, and capital investment. Most of the crops grown in plantation agriculture have a life cycle of 3 to 30 years. It is practiced in Kerala, Karnataka, Assam, Andhra Pradesh, and Maharashtra.

Allied Farming System

There are several other non-crop farming systems, under which farming of livestock for meat, milk, wool or poultry, fisheries, honeybee keeping, etc. are done at commercial scale. The produce from such farming are mainly sold in the market on continuous basis.

INTEXT QUESTIONS 3.3

1. Enlist the traditional farming systems followed in India.
2. Shifting cultivation is followed mostly in ………………………. states.
3. Dryland farming is practiced where rainfall is more than 1150 mm (True/False).
4. Give examples of two forest trees which are used as fodder.

3.6 CLASSIFICATION OF CROPS

A crop refers to group of plants sown and harvested for some definite economic purpose. In India, varieties of crops are cultivated by the farmers depending upon the soil type, agro-climatic conditions, market conditions, etc. These crops may be food crops as well as non-food crops. Major crops under different categories are given below in the box.

Field Crops

It is any of the herbaceous plants grown on a large scale in cultivated fields for agriculture purpose, primarily, grains, forage, sugar, oil and fibre. This includes other than fruits and vegetables. Field crops provide the food, feed, grain, oil and fibre for domestic consumption and are major component of a nation in progress.

Examples of field crops are cereals (rice, wheat, maize, sorghum, *etc*.) pulses (greengram, blackgram, redgram, bengalgram, *etc*.), oilseeds (sunflower, safflower, groundnut, sesame, *etc*.), fibre crops (cotton, jute, hemp, *etc*.).

FOOD CROPS: This includes cereals, pulses, fruits, vegetables, spices and condiments and other food crops.

Cereals: include paddy (rice), *jowar*, *bajra*, maize, *ragi*, wheat, small millets, barley and other cereals.

Pulses: include gram (chickpea), tur (redgram), urad (blackgram), moong (greengram), masur (lentil) and other pulses.

Notes

Fruits: include mangoes, bananas, citrus fruits (oranges, kinnow, etc.), apples, guavas, grapes, pomegranate, papayas, litchi, pine apple, and other fruits. Dried fruits include cashew nuts, almonds, pistachio, walnut and others.

Vegetables: include potato, tomato, onion, brinjal, cauliflower, spinach, carrot, ladies finger (bhindi), bottle gourd, bitter gourd, snake gourd, broccoli, mushroom, chillies, *Capsicum*, sweet potato, etc.

Spices & condiments: include black pepper, ginger, turmeric, cardamom, betel nuts (arecanuts), garlic, coriander, fennel, cinnamon, etc.

Other food crops: Sugar cane, water melons, musk melons, etc.

NON-FOOD CROPS: This crop group include those crops which are either not for human consumption purposes or consumed after certain processing. Such as:

Oilseeds: groundnut, rapeseed & mustard, sesamum, soybean, linseed, sunflower, safflower, coconut, nigerseed, cotton seed, castor seed, and other oilseeds.

Flowers and landscaping plants: Roses, *Chrysanthemum*, marigold, jasmine, and many other crops grown for gardens and fencing

Fibres: Cotton (*kapas*), jute, mesta, sunhemp, and other fibres

Plantation crops: Tea, coffee, rubber, cocoa, and others.

Drugs & narcotics: Tobacco and opium

Fodder crops: Berseem, napier, guar, fodder maize, and other fodder crops

Timber & agroforestry: Bamboo, teak, subabul, and other trees

Horticultural Crops

Horticultural crops include fruits (mango, grapes, guava, banana, *etc*.), vegetables (spinach, cabbage, cauliflower, tomato, brinjal, *etc*.), flowers (rose, lotus, jasmine *etc*.), medicinal (*tulsi*, aloe vera, garlic, *etc*.), aromatic (lemon grass, mint, fennel, *etc*.) and ornamental plants (marigold, rose, desert rose, lavender, *etc*.).

Commercial Crops

Cash crops or commercial crops are the ones that are cultivated to be sold in the market to earn profits from their sale. In other words, any crop grown to generate cash / profit rather than for subsistence is called cash crop. Example: Sugarcane, coffee, jute, cotton, *etc*.

Notes

Plantation Crops

Plantation crops are defined as a group of commercial crops perennial in nature, cultivated extensively in tropical and subtropical situations in large and contiguous areas. Example: Coconut, cashew nut, tea, coffee, oil palm, cocoa, *etc*.

INTEXT QUESTIONS 3.4

1. Commercial crops also known as …………………. crops.
2. Cereal, pulse, fruits, vegetables, spice and condiments come under …………..crops.
3. Plantation crops are …………….. in nature.
4. Soybean and niger are classified as

   a. Pulse crop　　b. Oilseed crop

   c. Cereal crop　　d. Fibre crop

3.7 IMPORTANCE OF ALLIED SECTORS OF AGRICULTURE

The allied sectors of agriculture play a crucial role in supporting and enhancing the overall agricultural system. These sectors contribute to the agricultural value chain by providing essential inputs, services, and processing activities. These sectors may benefit farmer through

a. Employment generation
b. Diversification of income sources
c. Supply of inputs
d. Nutritional security
e. Efficient resource utilization and waste management
f. Export of agricultural products
g. Conservation of biodiversity
h. Tackling harmful effects of climate change

The allied sectors of agriculture comprise livestock production - cattle & buffaloes, goats & sheep, poultry farming, fisheries, forestry and horticulture. In following section, we will discuss about some of these major sectors.

Livestock Farming

Livestock farming is an integral part of crop farming and contributes substantially to household nutritional security and poverty alleviation through increased household income. The returns from livestock especially dairying and mixed farming in small and medium holdings are larger and highly sustainable. The progress in this sector results in more balanced development of the rural economy and improvement in economic status of poor people associated with livestock. Indian agriculture is an economic symbiosis of crop and livestock production with cattle as the foundation. Dairy animals produce milk by converting the crop residues and byproducts from crops which otherwise would be wasted. Dairy sector contributes by way of cash income, draught power and manure.

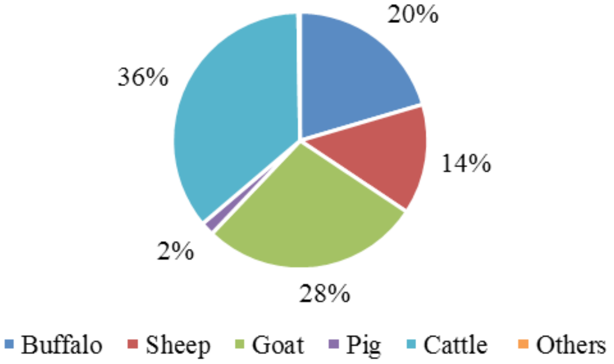


Fig. 3.6: Share of different livestock species in total population (2019)

Poultry

The number of poultry birds has increased to 851.81 million in the year 2019. It shows over 45.8% increase in backyard poultry and 4.5% in commercial poultry.

Table 3.4: Poultry population during 2012 and 2019

	Population (in millions)		% growth
	2012	2019	
Total poultry	729.21	851.81	16.81
Backyard poultry	217.49	317.07	45.78
Commercial poultry	511.72	534.74	4.50

Source: 20th Livestock Census Report, 2022

Notes

Fisheries

With about 7.7 per cent of the global fish production, India is the third largest fish producing country in the world. Fisheries and aquaculture witnessed manifold rise in its production during past decades, from 5 lakh tonnes in 1950-51 to 142 lakh tonnes in 2019-20.The sector provides livelihood to about 16 million fishers and fish farmers at the primary level and almost twice the number along the value chain, and has enough potential to generate income, employment, growth in subsidiary industries, and earn foreign exchange for the nation. Export earnings from the fisheries sector has been Rs. 46,662.85 crores during 2019-20.Fisheries sector has been recognized as a 'Sunrise Sector' and has demonstrated an outstanding double-digit average annual growth of 10.87 per cent since 2014-15.

Table 3.5: Fish production in India (2019-20)

Sl. No	Type of fish	Production (000 tonnes)
1.	Inland fish	14164.00
2.	Marine fish	3727.00

Source: India Stat, 2022

3.8 SOURCES OF IRRIGATION IN INDIA

Irrigation is the artificial application of water to the soil or agricultural field. It is essential for sustaining crop productivity in many regions of the country mainly because the rainfall is inadequate and unevenly distributed to meet crop-water demands. Irrigation helps grow and cultivate crops. Major sources of irrigation water in India are rivers, rainwater, groundwater, open well, tube well, tanks, canals, *etc*.

The competing demands of water for other uses, *viz*. urbanization and industrialization, are also restricting the availability of water for crop production. Therefore, it is essential to optimize the use of water according to availability on a sustainable basis. In most part of the country, due to overuse of groundwater, the water table is declining. In India, various irrigation systems are used, like surface irrigation (check basin, border strip, furrow), sub surface irrigation (drip irrigation) and pressurised irrigation (drip and sprinkler irrigation). Drip irrigation, a green revolution technology, has been introduced to reduce the tillage requirement and increase the water-use efficiency by 40-80 per cent.

INTEXT QUESTIONS 3.5

1. Which allied agricultural sector is considered as 'Sunrise sector of India'?

2. By using drip irrigation method, water use efficiency can be increased by

   a. 40 to 80% b. 10 to 40%

   c. 40 to 78% d. 20 to 40%

3. Name few major sources of irrigation used in India.

WHAT YOU HAVE LEARNT

- A farm is a piece of land, where crops and livestock production are taken up by the household or farmer. Agricultural labour is basically a semi-skilled or unskilled person employed to a farm in connection with cultivating the soil or performing any farm operations.
- In India, lands are utilized for various purposes like agriculture, forest, pasture, grazing or non-agricultural use (road, railways, buildings or factories).
- Based on size of landholding, farmers are categorized into various classes. Small and marginal farmers form the majority of farming community
- A farming system is a combination of several farming activities, such as crops, livestock, aquaculture, agro-forestry and fruit crops by farmer to maximize productivity and farm income.
- There are eight major types of soils in India *viz.* alluvial soil, red soil, black soil, laterite soil, arid soil, forest soil, saline-alkaline soil and peaty-marshy soil.
- India has been divided into 15 agro-climatic zones based on temperature, annual rainfall and topography.
- Different sources of irrigation in India include surface irrigation (check basin irrigation), sub surface irrigation (drip irrigation) and pressurised irrigation (drip and sprinkler irrigation).

Notes

TERMINAL QUESTIONS

1. Explain the main characteristics of Indian agriculture.
2. Give a brief overview of different farming systems.
3. Define a crop? Can you provide examples for the different classifications of crops?
4. Could you list the types of soils found in India and discuss the features of alluvial soil in detail?
5. Can you provide a detailed description of the 15 agro-climatic zones in India?
6. What are the various sources of irrigation used in India?
7. Could you write down the importance of drip irrigation?

ANSWERS TO INTEXT QUESTIONS

3.1

1. 139.35 million hectare
2. Small and marginal farmers
3. < 1 ha (option c)
4. 328.7 Mha (option b)

3.2

1. 15 (option b)
2. Both b & C (option d)
3. Black soil
4. Arid soil

3.3

1. Shifting cultivation and subsistence farming
2. North eastern states
3. False
4. Subabul and Khejri

3.4

1. Cash crops
2. Food crops
3. Perennial
4. Oilseed crop (option b)

3.5

1. Fisheries sector
2. 40-80% (option c)
3. Rivers, rainwater, groundwater, open well, tube well, tanks, canals

GLOSSARY

Agroforestry: Agroforestry is the integration of woody perennials, such as trees and shrubs, with crops, livestock, or fish production.

Cropping intensity: Ratio of gross cropped area and net sown area in percentage term is called cropping intensity.

Current fallow: The areas which are usually cropped but due to some reason or the other were not cultivated during the reference year are classified as current fallow.

Farming system: A farming system is a mix of farm enterprises such as crops, livestock, aquaculture, agro-forestry and fruit crops to which farm family allocates its resources in order to efficiently manage the existing environment for the attainment of the family goal.

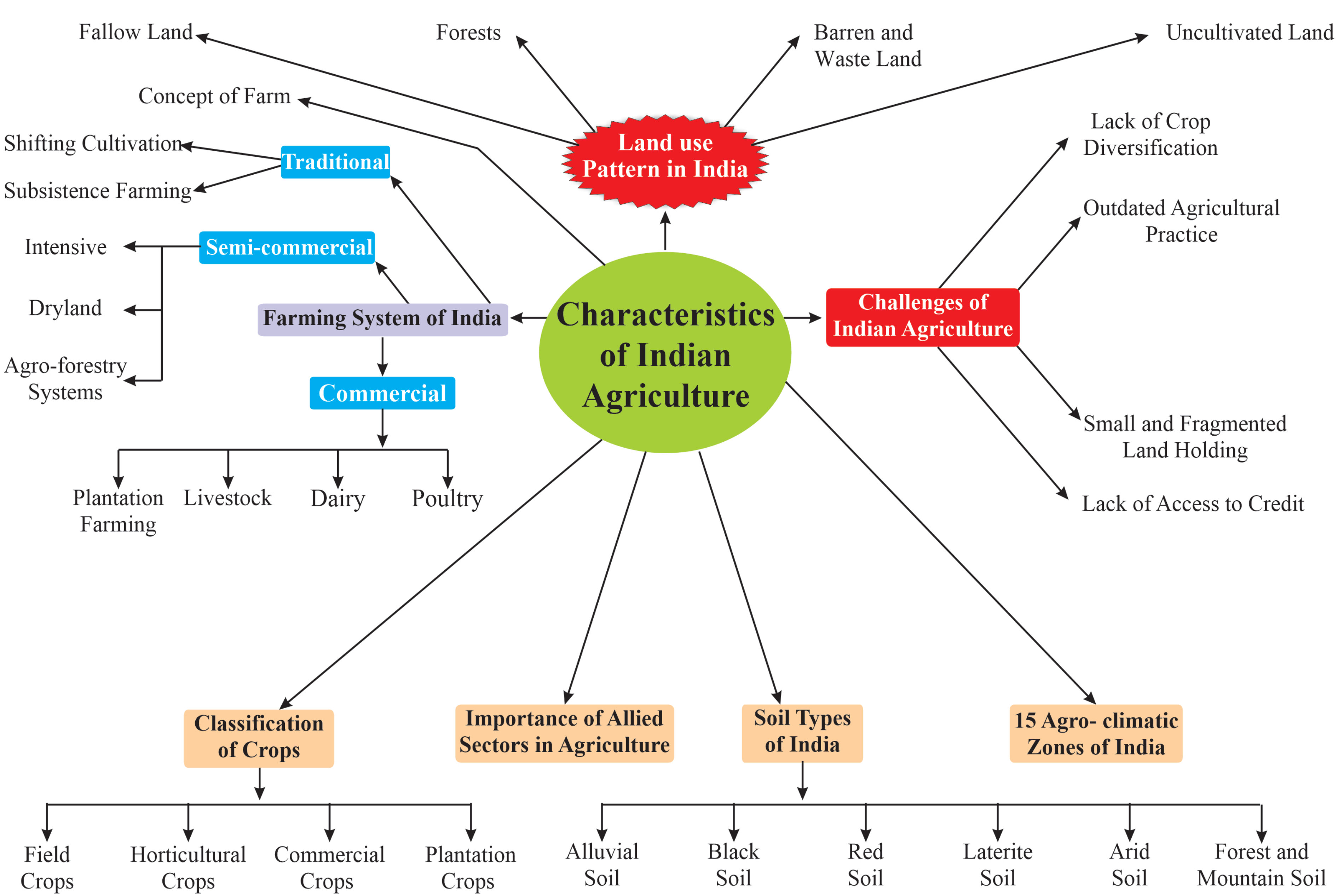
Gross cropped area: Area sown more than once in an agricultural year plus net sown area is known as gross cropped area.

Net sown area: The Net Area Sown represents the total cultivated area during the reference year without considering the number of times it has been cultivated in a year.

SUGGESTED READINGS

1. *Handbook of Agriculture*, 6th edition, Indian Council of Agricultural Research, New Delhi.
2. Chadha, K. L. (2019). *Handbook of Horticulture* (Vol. I & II), ICAR Publication, New Delhi.

WHAT YOU HAVE LEARNT



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NEW DEVELOPMENTS IN AGRICULTURE

In the previous lesson, you have learnt about the challenges faced by Indian farmers. Have you thought about any solution to these problems? One possible solution may be the use of advanced technologies in agriculture. Agricultural practices and agriculture businesses have evolved in recent years in a variety of ways. The main goal of all the improved technologies is utilizing the resources more efficiently, boosting the crop yields and minimizing the risks. Time-tested practices like crop rotation, integrated nutrient and pest management, conservation tillage combined with new agricultural technologies, such as monitoring field productivity with sensors and satellite images or special farming software, all contribute to the sustainable growth of agriculture.

Let's discuss some of these advanced technologies which can help to reduce the misery of farmers.

LEARNING OUTCOMES

After studying this lesson, the learner:

- explains about the recent advancements in Indian agriculture;
- describes the role of emerging technologies and precision agriculture in crop production;
- defines the farm automation;
- discovers modern practices of crop production; and
- states the role of Agritech startups and FPOs in agricultural revolution.

4.1 EVOLUTION OF AGRICULTURE TECHNOLOGY

Technological advancement in agriculture is essentially needed to counter the huge number of challenges that Indian agriculture faces, right from seed sowing to crop harvesting and marketing of the produce. These technological developments have happened in different phases over the years. It was more evident for the first time during the 'Green revolution' period in mid-sixties when short duration crop varieties of rice and wheat were combined with chemical fertilizer and irrigation. The technological model of agricultural production until the early 20th century remained largely subsistence type characterized by poor productivity. This era is known as "**Agriculture 1.0**" marked by the widespread use of animal drafts.

Agriculture 2.0 started towards the end of the 19th century with the introduction of machinery, such as tractors. Later, agricultural technology underwent several transformations.

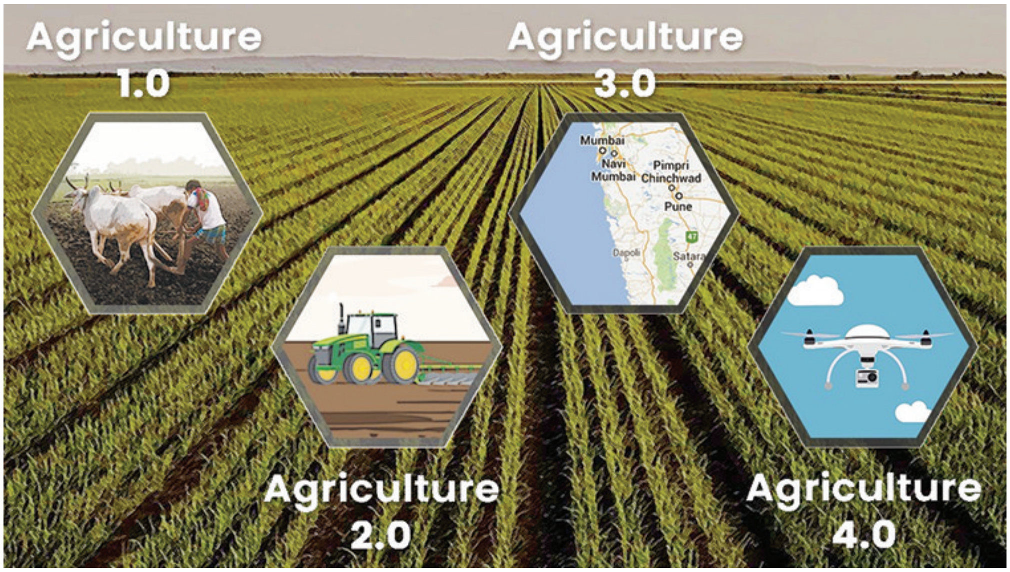


Fig 4.1: Evolution of Agriculture Technology

Agriculture 3.0 may be characterized by precision or smart farming, which evolved out of the need to track and manage all inputs into crop production more efficiently. The pursuit of precision agriculture and its associated agricultural technology have led to the development of new farming methods and tools. The Global Positioning System (GPS) came as the breakthrough technology that is transforming agriculture in a big way. Now, with further technological development, we are experiencing smart farming, in which all the information from the fields and surrounding environment are collected at real-time and decision making is done based on the facts and field-level evidence.

Agriculture 4.0 or **Digital agriculture** refers to the next generation of farming methods in which emerging digital tools are used for maximizing crop yields and other agricultural outcomes. Technologies like automatic machines, sensor-equipped robots, the Internet of Things (IoT), drones, and satellites are all part of the new agricultural environment, named Agriculture 4.0.

Augmented Reality (AR) vs Virtual Reality (VR) and IoT

Augmented reality (AR) layers digital objects on top of your live view of the immediate physical surroundings via the camera on a smartphone or tablet. The user is immersed in a mix of the real world and a virtual world. Interacts simultaneously with both the worlds using smartphone or tablets. Virtual reality (VR) is a completely immersive experience that transforms your physical surroundings into a digital world via a head-mounted display. In this case, it is hard to differentiate between real and virtual world.

For example, one may introduce virtually a new harvesting machine in the picture of actual crop field using AR and see the effectiveness. In case of VR, we can have completely simulated environment of crop field and machine.

On the other hand, **IoT** or **Internet of Things** is a broad term given to every object that can relay information seamlessly when connected to the network. For example, by placing sensors, robots, and cameras inter-connected with smartphone, one may monitor and operate the farm even from a far away location.

4.2 FARM LEVEL MODERNIZATION

Laser Land Leveling

Laser leveling is a process of smoothing the land surface from its average elevation using laser equipped drag buckets. This practice uses high-power tractors and soil movers that are equipped with global positioning systems (GPS) and/or laser guided instrumentation so that the soil can be moved either by cutting or filling to create the desired slope/level. This technique is well known for achieving higher levels of accuracy in land leveling and offers great potential for water savings and higher grain yields. A laser transmitter transmits a laser beam, which is intercepted by the laser receiver mounted on the leveling bucket. The control panel mounted on the tractor interprets the signal from the receiver and opens or closes the hydraulically controlled bucket to collect and drop the soil where it is needed to make the field near absolute level.

Notes

Benefits of Laser Land Levelling.

- A precisely leveled surface leads to uniform soil moisture distribution, resulting in good germination, enhanced input-use efficiency and improved crop stand and yield.
- Laser leveling allows for control of water distribution with negligible water losses.
- Laser leveling improves irrigation efficiency and reduces the potential for nutrient loss through better irrigation and runoff control.
- It facilitates uniformity in the placement of seedlings, helping to achieve higher yields.
- Land leveling reduces weed (improved water coverage reduces weeds up to 40%), pest, and disease problems.
- It results in 3 to 4% additional land recovery and improves operational efficiency (reducing operating time by 10-15%).
- It leads to reduced consumption of seeds, fertilizers, chemicals and fuel.
- It facilitates movement of agricultural machinery through the fields.

Fig. 4.2: Tractor-mounted laser land leveller

Precision Farming

Precision farming is about doing the right thing, in the right way and at the right time. With the help of precision farming, agricultural inputs such as seed, fertilizer, water, etc. are applied in the needed quantity whenever crops need these inputs to increase yield, quality, and profit. It is also an agricultural resource management strategy that collects, processes, and evaluates data and offers insights to help farmers optimize and increase soil quality and productivity.

New precision agriculture technologies allow the farmers to control every variable of crop farming, such as moisture levels, soil conditions, and soil nutrients. It may involve the use of sensor technology, AI (artificial intelligence), GIS, and IoT to collect and analyze data about the soil, plants, and animals. It allows for more targeted use of inputs, such as water, fertilizer, plant nutrients, pesticides, seeds, and labour.

Micro-irrigation

Micro-irrigation is a modern method of irrigation in which water is applied on the land's surface or below the surface using drippers, sprinklers, foggers, and other emitters. The major components of a micro-irrigation system include water supply, pumping devices (motor and pump), ball valves, fertigation equipment, filters, control valves, PVC joining accessories (main and sub-main) and emitters.

Types of Micro Irrigation

A. Sprinkler Irrigation

Sprinkler irrigation is a method of applying irrigation water like natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops and falls on the standing crops. This kind of irrigation system helps uniform application of water in the field irrespective of field topography. The research conducted in different parts of the country measured water saving due to sprinkler system ranging from 16 to 70% over the traditional method with yield increase from 3 to 57 % in different crops and agro-climatic conditions. Sprinkler irrigation is suited mostly for field and tree crops grown in rows.

Fig 4.3: Sprinkler irrigation system

Notes

Drip Irrigation

Drip irrigation is sometimes called trickle irrigation and involves dripping water onto the soil at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to plants so that only part of the soil in which the roots grow is wet, unlike surface and sprinkler irrigation, which involves wetting the whole soil profile. Crops suitable for drip irrigation system are orchard crops (e.g., mango, grapes), vegetables, plantation crops, wider row crops like sugarcane, maize, cotton, mustard, pigeonpea etc. Now the emphasis is being given on extending the use of drip irrigation to close growing crops like wheat, chickpea, soybean etc.

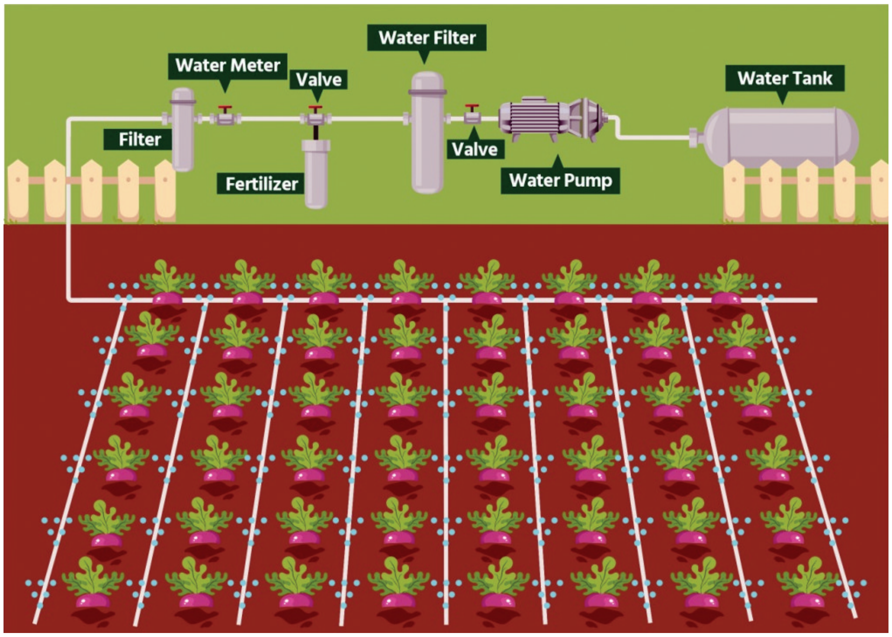


Fig 4.4: Drip irrigation system

Benefits of Drip Irrigation:

- Improvement in crop yield up to 200 %
- Water saving up to 70% compared to flood irrigation. Additional land can be irrigated with the water saved.
- Crop grows consistently, healthier and results in higher yield.
- Increase in fertilizer-use efficiency by 30%
- Expenditure on fertilizers and labour use reduces.

- Undulating terrains, sandy & hilly lands can also be brought under productive cultivation.
- Water-use efficiency can be as high as 90%.

INTEXT QUESTIONS 4.1

1. If you are having an undulating land where paddy is to be grown, which management practices will you adopt?
2. Land levelling reduces the operating time by

   a. 5-10% b. 10-15%

   c. 15-20% d. 20-30%
3. .... is a method of applying irrigation water which is similar to natural rainfall.
4. Water saving by sprinkler system is around

   a. 16% to 70% b. 30% to 50%

   c. 60% to 75% d. 70% to 90%

4.3 FARM AUTOMATION

Farm automation brings together agricultural machinery, computer systems, electronics, chemical sensors, and data management to improve equipment operation and decision-making, and ultimately, reduce human error. Reduced labor time, higher yields, and the efficient use of resources are driving the large-scale adoption of the technology. Farmers now use automated harvesters, drones, autonomous tractors, seeding, and weeding to transform how they cultivate their crops. Technology takes care of menial and recurring tasks, allowing them to focus on more critical functions. Automation can help employees save time, as the technology reduces the need for people to actively partake in a task. Thanks to automation, most farmers now spend more time with their families than before.

A. Modern Greenhouses

Greenhouse technology provides an opportunity to control the climate in which crops can be grown. With improvements in growing technology, greenhouse

Notes

crop cultivation is witnessing a boom. One can regulate almost all the parameters needed for the crop growth like temperature, moisture, CO_2 level, light intensity, etc., depending upon the capital investment made in the greenhouse.

Fig 4.5: Crops cultivation inside a greenhouse

The entire global greenhouse market currently produces nearly US $350 billion in vegetables annually. As the demand for high value crops is growing round the year, modern greenhouses are becoming increasingly tech-heavy, using LED lights and automated control systems to perfectly tailor the growing environment. Successful greenhouse companies are scaling up significantly and locating their growing facilities near urban hubs to capitalize on the ever-increasing demand for local food.

B. Artificial Intelligence (AI)

Artificial intelligence (AI) is a branch of computer science that focuses on building and managing technology that can learn to autonomously make decisions and carry out actions on behalf of a human being. These can monitor plant health, soil conditions, temperature, humidity, and more. The idea is to give farmers a better understanding of what's happening on the ground through advanced technology that can tell them more than a naked eye can see. Not only is it more accurate, it's also faster. The goal is to enable farmers to use this artificial intelligence to make better decisions in the field, thereby achieving their goals of better harvests.

Artificial intelligence is going to bring the next revolution in agriculture. Right from sowing the seeds to nutrients and irrigation management to pests' predictions, AI will enable farmers to get the best results for their hardwork. This will also contribute in determining the best practices; be it choices of seeds, fertilizers or pesticides or the technique deployed at a particular stage of farming. Similarly, IoT (Internet of Things) is used as a smart farming solution for monitoring the crop field from anywhere. This technology connects different electronic devices and shares the information seamlessly in real time. This technology is being used in several on-farm and off-farm operations. Farmers are now able to operate irrigation pumps from anywhere, as the field level irrigation information can be shared on his smartphone.

C. Mobile Technology in Agriculture

Mobile applications related to agriculture are now gaining importance. With a specific application, one can see the entire field map on the mobile. Crop monitoring mobile app allows you to keep eyes on a field's vegetation from anywhere. One can track the weather in the field, plan and manage scouting tasks, and get updates on the current situation all from the convenience of his mobile device.

D. Robotics in Agriculture

Use of robots in agriculture is still in preliminary stage in India. However, with the rising cost of human labour, we may expect wide application of robots in near future. In 2022, the global market size of agricultural robotics was nearly $5 billion. Many farming activities performed by humans can be done by these robots or agribots. Though at pilot stage, these agribots are being used in seed planting, crop harvesting, weeding, sorting and packaging, livestock management, etc. The autonomous performance of such robots allows for continuous field management and improves agricultural productivity. Several new agri-entrepreneurs are venturing into this field to provide the services of agribots in India.

Notes

Fig. 4.7: Application of robotics in agriculture

E. Remote Sensing Technology in Agriculture

The use of satellites in agriculture started long back for collecting crop data and monitoring the crops at large scale. Satellite sensors monitor, measure, and record the electromagnetic radiation reflected or emitted by the crops on earth for further analysis and data extraction. With this technology, one can track crop growth throughout the season even in vast, inaccessible areas. This information is beneficial for various purposes, including crop forecasting and policy making.

a) **Satellite Imaging:** India is planning to have dedicated satellites for agriculture, which will help in continuous monitoring of farm-related activities like crop forecasting, pesticide application, irrigation, soil data, and generation of critical data related to drought. It would allow real-time crop imagery. Crop imagery lets a farmer examine crops as if he or she were standing there without being present in field. Even reviewing images on a weekly basis can save a farmer's considerable amount of time and money. Additionally, this technology can be integrated with crop, soil and water sensors so as to help the farmers make critical decisions.

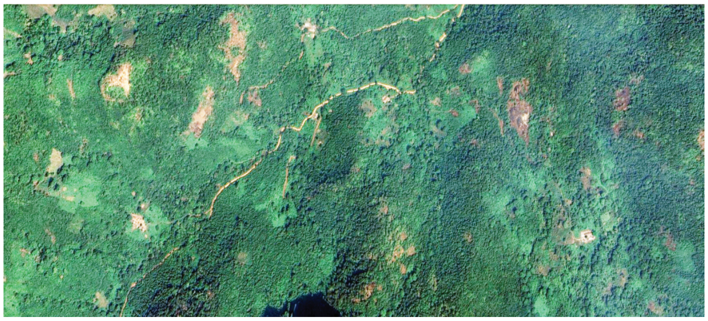


Fig. 4.8: Vegetation monitoring using satellite imagery

b) **Geographic Information Systems (GIS)** are essential for the storage, analysis, and visualization of spatial data for precision agriculture needs. One of the most important ways that GIS-based agriculture technology is used in farming is to gather information about a region's crops, soil, climate, and topography by using satellites and drones. In livestock rearing, GIS software monitors the movement of animals. This, in turn, will help farmers track animals' health, fertility, or nutrition.

Furthermore, GIS in agriculture enables the use of applications in conjunction with smart tools to optimize the spreading of fertilizer and pesticides. By using these maps, it's easy to pinpoint the most productive parts of your field, as well as low-yielding places that would benefit from additional fertilizer or other methods to boost field productivity.

Notes

F. Weather Tracking

Although we depend on local weather experts/meteorologists for weather information, the truth is that computerized weather modeling is becoming more popular. There are online weather services that focus exclusively on agriculture, and farmers can access these services on their smartphone. This technology can give farmers enough advanced notification about hailstorm and other weather events so that they can take precautions to protect the crops or at least minimize the losses to a significant extent. Some agri-tech startup companies provide a farm-specific micro-climate forecast for the next 14 days to keep you well prepared for weather risks of the future.

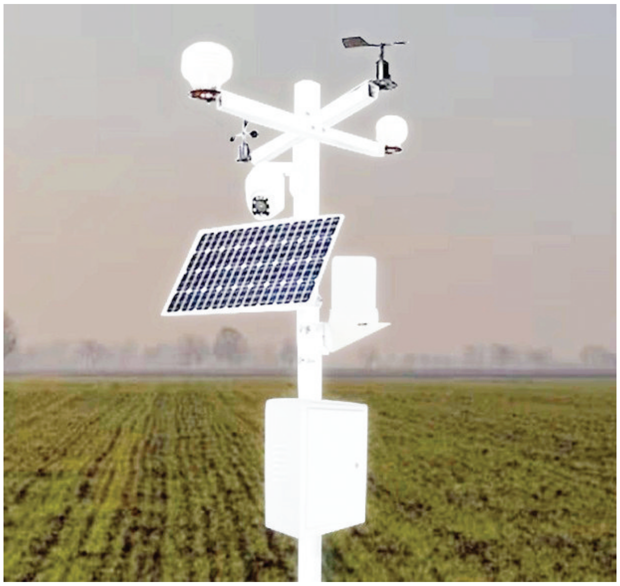


Fig 4.10: Sensors installed in the field for weather forecast

Notes

G. Livestock Farming Technology

Emerging livestock technologies provide farmers with data-driven insights, allowing them to streamline farm management, improve animal care, and boost productivity. Here are some of the many innovations redefining livestock farming:

- **Automated dairy installations** milk cows automatically without human intervention.
- **Automated cleaning systems** remove waste, enabling cleaner and disease-free environment.
- **Automated feeder systems** provide animals with feeding mixtures tailored to their specific needs and in the right amount.
- **Digital monitoring of animals:** Every animal wears an electronic device attached to the collar. It is a battery-powered microcontroller device equipped with low-power inertial sensors (accelerometer and magnetometer) and wireless communication. This technology can enhance the welfare and management of animals. This 'connected cow' concept is the result of equipping herds with sensors to monitor their health and increase productivity. By attaching individual wearable sensors to cows, producers can keep track of daily activity and health-related issues and make operational decisions quickly and easily.

Fig. 4.11: Digital monitoring of animals through sensors

Notes

H. Farm Management Software

It is an integrated platform that provides real-time data and information, like a digital checklist, to assist farmers in tracking daily activities. With this monitoring and reporting software, farmers can improve decision-making throughout all operations. There are some enterprise resource planning solution available in the market that allow farms to streamline their processes and enables seamless collaborations. It lets users manage procurement, supply chain, finances, and processing from a single hub. This innovation in agriculture technology will continue to advance as internet-enabled devices become ubiquitous in future.

I. Drone Technology in Agriculture

Drones, also known as unmanned aerial vehicles (UAVs), are becoming quite common in the agricultural industry. Drones are being used for different purposes. Equipped with different technology-based sensors, drones can be used in precision agriculture – monitoring crop health, weed and pest detection, crop scouting, analysis of soil health, irrigation management, monitor field temperature, and spray pesticides or fertilizers at desired locations on the field.

In animal husbandry, drones are used to observe grasslands and track animal movements on big ranches. Some drones have thermal imaging cameras to detect sick animals with high body temperatures. The inherent benefits and the rise of drones in farm operations lie in their ability to help farmers acquire comprehensive data to make timely decisions.

Fig. 4.12: Spraying of pesticide through drones

Notes

INTEXT QUESTIONS 4.2

1. The role of Global Positioning System (GPS) is

   a. Soil testing b. Soil sampling

   c. Nutrient analysis d. All of the above

2. Which of the following is used in seed planting, crop harvesting, weeding, and sorting?

   a. GIS b. GPS

   c. Agribots d. None of the above

3. The drones can be used in precision agriculture for

   a. Monitoring crop health

   b. Spray pesticides or fertilizers

   c. Crop scouting

   d. All of the above

4. If your father is having 10 acres of paddy crop, which method will you suggest him to spray pesticides during the period of labour shortage?

5. Which method can be used to examine the crops without actually standing there?

4.4 MODERN PRACTICES IN AGRICULTURE

Indoor Vertical Farming

Vertical farming has been a science fiction topic in the 1950s and later, but now it’s not only scientifically possible but also becoming financially viable. Vertical farming, a component of urban agriculture is the practice of growing crops in vertically stacked layers. This offers many advantages like

- Perhaps the most obvious is the ability to grow crops in land constrained environments.
- Indoor vertical farms enable growers to control variables such as light, temperature, humidity, water, and sometimes, carbon dioxide levels, allowing them to get healthier and better yields throughout the year.

- Vertical farms use up to 70% less water than traditional farms.

Quite often, the stacked layers don't require soil to grow plants. Based on type of technology used, they're either hydroponic or aeroponics system.

I. **Hydroponics** is a type of indoor vertical farming where plants grow in water and nutrient solutions.

II. **Aeroponics:** Here roots of the crops are suspended in the air. Water and nutrients are sprayed intermittently in the form of mist with help of emitters.

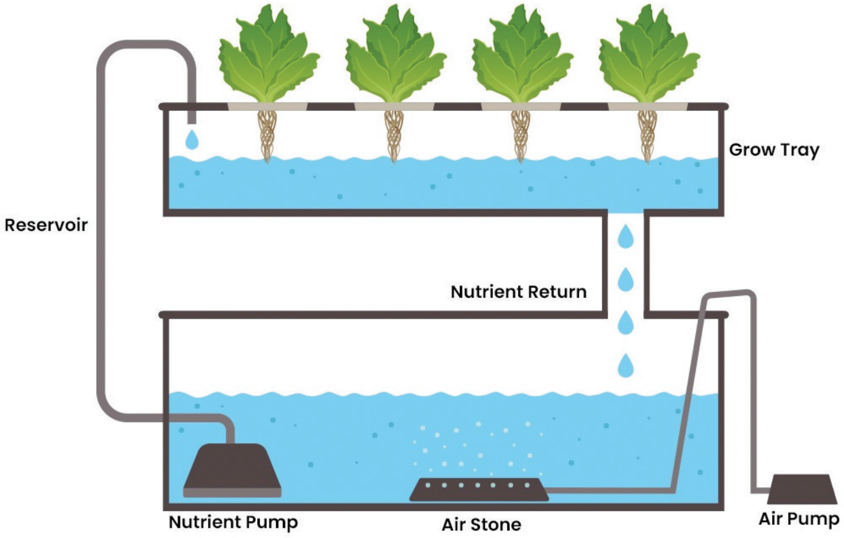


Fig. 4.13: Hydroponics

Genetically Modified Crops

Genetically modified crops or GM crops are the special type of plants used in agriculture, whose genetical make up has been modified using genetic engineering techniques. GM crops are created mostly with the aim of

- Introducing a new character (e.g. resistance to certain pests, diseases, environmental conditions, herbicides) in the plant which does not occur naturally in the species. For example, Bt-cotton in India.
- To increase nutritional value and for other purposes like production of pharmaceutical agents, biofuels etc. For example, Vitamin A enriched golden rice variety.

At present, the only genetically modified crop that is under cultivation in India is Bt-cotton which was grown over 11.9 million hectares in 2022. Bt cotton was first used in India in 2002, which is resistant to one of the most damaging insects of the crop *viz.* bollworm.

Notes

INTEXT QUESTIONS 4.3

1. …………….. and ………… are the methods of growing plants without soil.
2. The genetically modified crop which is being cultivated in India

   a. Rice b. Wheat

   c. Sugarcane d. Cotton
3. In hydroponics system, plant roots are suspended in air (True/False).

4.5 AGRITECH STARTUPS AND FPOS

In India, more than 86% of farmers are smallholders who have little understanding of modern farming methods and techniques. Several types of startups in agriculture and allied sectors have come up in the last decade that are filling the gaps in the food value chains. Innovation based agri-startups are basically working in six areas:

1) Those providing output market linkages
2) Those facilitating input supply
3) Enabling mechanisation, irrigation control and financial support
4) Helping in quality maintenance, monitoring, traceability and output predictions
5) Post-harvest management and farming as a service
6) Those supporting animal husbandry farmers

Connecting small and marginal farmers with these entrepreneurs can build a more equitable and sustainable food system for India. But how can it be achieved? The solution to this question lies in the establishment of Farmer Producer Organisations (FPOs).

Equipping FPOs with Entrepreneurial Innovations

FPOs (Farmer Producer Organisations) are farmers' organisations that bring farmers together, make them more efficient buyers of agricultural inputs, and more effective sellers of their products. By pooling resources, they can also help farmers access new technologies that can improve their yields over the long run. FPOs work in every agriculture field of India, from field crops, horticultural crops, dairies, fisheries and poultry. Currently, there are more than 25,000 FPOs registered in different forms in India.

With typical holdings of less than one hectare, farmers individually cannot afford to invest in mechanization or technology to enhance productivity, procure key inputs at a low price, or directly access buyers. Aggregation through FPOs is the only feasible option left for farmers to enhance their bargaining power and accrue more value. Here is where start-ups can come in. Young businesses with the ambition to scale up and provide reliable real-time support to small farmers can benefit massively from working with FPOs. They can build socio-economic resilience into agricultural supply chains, improve food and nutritional security, and build strong businesses that create wealth in rural areas. In coming years, we may expect that agri-startups and FPOs work hand-in-hand for sustainable development of agriculture and ensuring remunerative incomes for the farmers.

INTEXT QUESTIONS 4.4

1. FPO stands for ....
2. The areas where agri-startups operate in India are ....
3. What is the feasible option available for farmers to enhance their bargaining power?

WHAT YOU HAVE LEARNT

Feeding the rapidly increasing global population amid the climate crisis is a big challenge. Traditional farming cannot provide food at the speed and accuracy to feed this population. The technology delivers solution to such problem. New innovations in agriculture have shown us how technology can help us build more sustainable food systems and improve food security. Over the past five decades, digitization has resulted in the radical transformation of agriculture by improving its speed, scale, and productivity globally. Agriculture 4.0, the fourth agricultural revolution, has provided agri-stakeholders with a broad range of technological options to choose from to help them achieve their goals, be it remote sensing and GPS technologies, artificial intelligence, connected sensors, IoTs, or many other emerging technologies. Mounting pressures on the environment are also redirecting scientists' approach to the way we farm today. The road to sustainable farming requires significant investments in infrastructure and technology infusion, but its success can ensure that the current and future generations can live comfortably with the resources available.

Notes

TERMINAL QUESTIONS

1. Enlist the recent advanced technologies in agriculture.
2. Discuss about laser land leveling and its benefits.
3. Define precision farming and micro-irrigation. Mention the types of micro- irrigation.
4. Discuss the methods that are used to produce off-season crops.
5. Write a short note on controlled environment agriculture.
6. Discuss the role of AI in agriculture.
7. Discuss livestock farming technology and its areas of innovation.
8. Give a detailed note on the remote sensing technology in agriculture.
9. Explain the greenhouse technology.
10. Discuss how FPOs and Agritech Startups help marginal farmers?

ANSWERS TO INTEXT QUESTIONS

4.1

1. Laser land leveling
2. 10-15% (Option b)
3. Sprinkler irrigation
4. 16-70% (Option a)

4.2

1. Soil sampling (Option b)
2. Agribots (Option c)
3. All of the above (Option d)
4. Drone technology
5. Satellite imaging

4.3

1. Hydroponics and aeroponics
2. Cotton (option d)
3. False

4.4

1. Farmer producer organization
2. Agriculture, Dairies, non-timber forest produce, poultry, honey production
3. Aggregation through FPOs

GLOSSARY

Augmented reality (AR): It is an interactive experience that enhances the real world with computer-generated perceptual information

Dry land farming: Cultivation of crops in areas receiving rainfall above 750 mm but less than 1150 mm is known as dryland farming.

Genetically modified crops: GM crops are the special type of plants whose genetical make up has been modified using genetic engineering techniques.

Marginal farmer: The farmer who has less than 1 hectare of agricultural land where he carries on agricultural activities as a proprietor, sharecropper, or tenant.

Precision farming: It is combination of information technology (IT), information communication technology (ICT) and sound agronomic practices intended for improving crop productivity, resource use efficiency and preventing harm to environment.

The Internet of Things (IoT): It is defined as the use of synched data on various platforms to exchange necessary information in real-time using the internet.

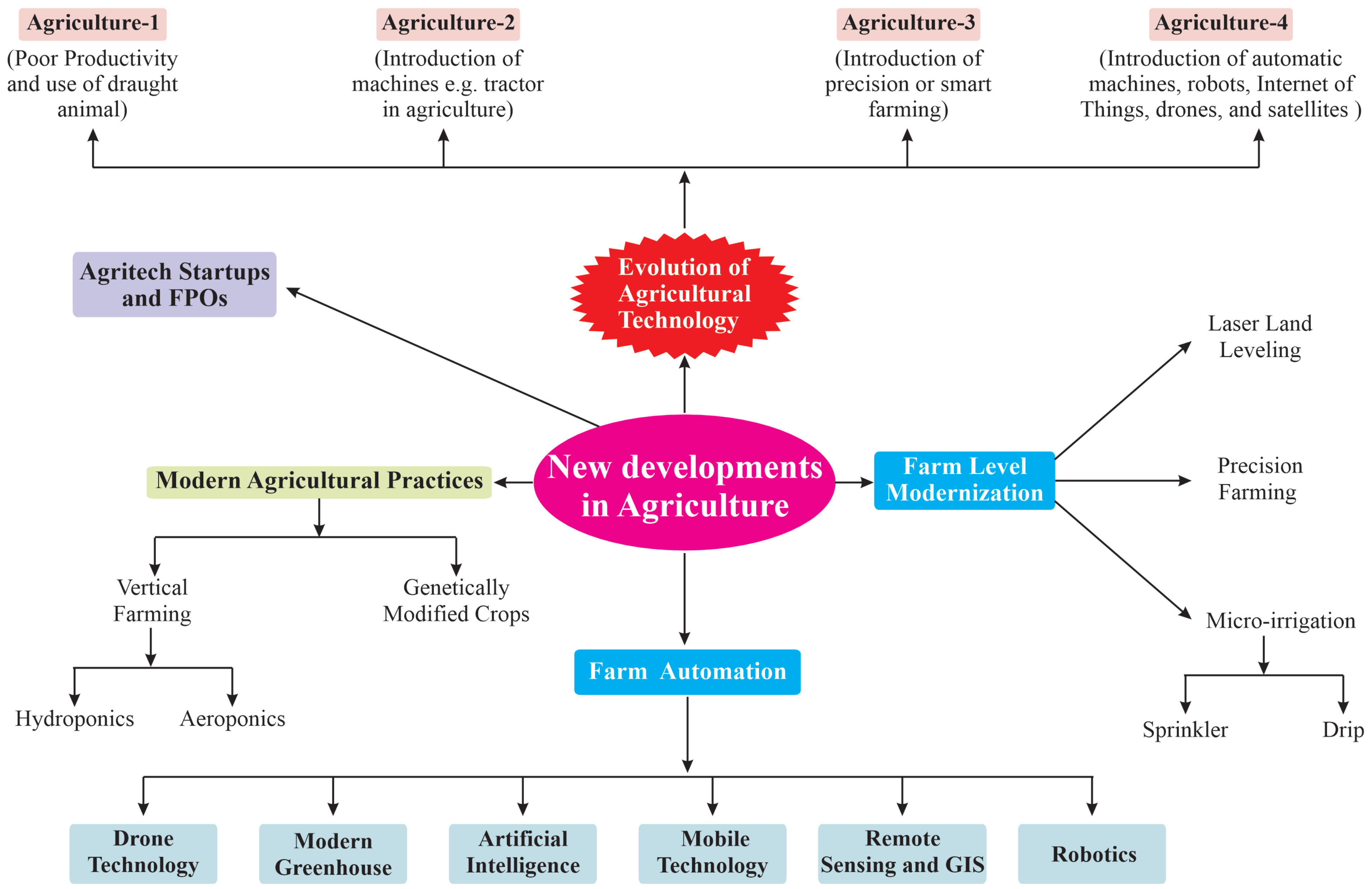
Vertical farming: It is an agricultural technique which involves growing crops in layers that are stacked vertically.

Notes

SUGGESTED READINGS

1. *Handbook of Agriculture*, 6^{th} edition, Indian Council of Agricultural Research, New Delhi.
2. Dass, A., Choudhary, A. K., Sudhishri, S. and Rajanna, G. (2019). *Precision crop and resource management*, ICAR-IARI, New Delhi.
3. Kumar, S., Saravaiya, S. N. and Pandey, A. K. (2022). *Precision Farming and Protected Cultivation: Concepts and Applications*, Narendra Publishing House, Delhi.

WHAT YOU HAVE LEARNT



MODULE -2

Crop Production Practices

5. New Developments in Agriculture
6. Crops, Cropping System and Crop Establishment
7. Nutrient, Water and Weed Management
8. Plant Protection and Harvesting
9. Fundamentals of Horticulture and Fruit Production
10. Vegetable Crops
11. Flower Crops

5

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SOIL HEALTH AND PLANT NUTRITION

The soil is a natural resource which is intensively utilized for crop production. It acts as primary medium for crop growth and sustenance. Plant obtains their food materials and water from soil. It also provides mechanical support to crops. Soil is also living place of numerous other living organisms like algae, bacteria, fungi, virus, etc. These organisms help in plant nutrition and protect the environment. Therefore, soil is called as soul of infinite life. So you can understand how soil plays a critical role in agriculture. As the cultivable land is decreasing day-by-day due to increased population, we need to manage the soil more efficiently for food production. This requires scientific knowledge about soil. In this lesson, we will study about fundamental principles about soil and its management.

LEARNING OUTCOMES

After studying this lesson, the learner:

- summarizes the importance of soil in agriculture and human life;
- explains how a soil is originated from parent rocks;
- supports the farmers to manage the soil sustainably for crop production; and
- discusses the techniques for protection of soil from erosion and degradation.

5.1 SOIL AS A NATURAL BODY FOR PLANT GROWTH

Soil is a precious natural resource that supports outdoor plant growth. It is a thin-layer 3-dimensional polyphasic dynamic natural body on upper portion of the earth's crust which supports plant growth. It is called polyphasic system because soil contains solid, liquid and gaseous phases. Millions and millions of micro organisms are residing

Notes

in soil; therefore, it is considered as a living body. They help in nutrient transformations for the support of plant growth. For this reason, Franklin Roosevelt (32nd President of USA) said '*A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people*'. Soils have developed over a long period of time in a place through natural processes, following natural laws, under natural conditions and from natural materials. That's why soil is considered as a natural body.

5.2 COMPONENTS OF SOIL

Soil is a thin-layer material on upper portion of the earth's crust present in between bedrock and air. An ideal soil consists of mineral matters (45%), organic matter (5%), soil air (~25%) and soil water (~25%).

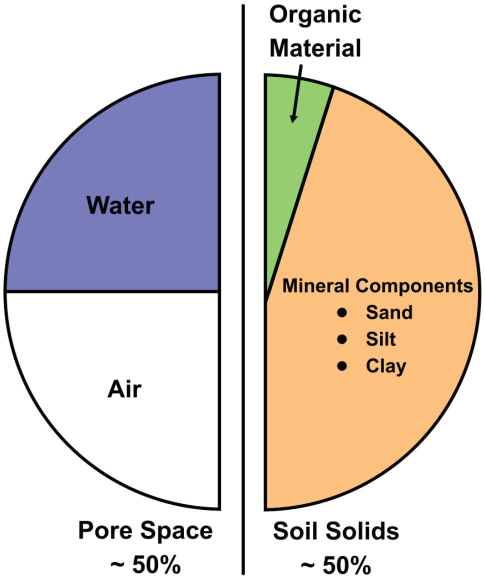

Fig. 5.1: Components of soil

5.2.1 Mineral Matter

Major part of solid portion of the soil is mineral matter. It includes sand, silt and clay. It is composed of primary and secondary minerals. Primary minerals like quartz, mica and feldspar are similar to soil parent materials, whereas secondary minerals such as silicate clay, limonite, haematite are originated from primary minerals. The primary minerals dominate in the coarser fraction of soils. The secondary minerals are prominent in the fine soil particles, especially in clay fraction. The size of these particles does have much effect on the properties of soil.

5.2.2 Organic Matter

Soil organic matter includes the decomposed organic materials, partially decomposed and partially synthesized plant and animal residues in the soil. They are continuously decomposed by microbial action. Plant residues are the primary source of organic matter in soil and animal residues are secondary source.

Mineral matter and organic matter of soil are the inorganic and organic constituents, respectively. Soils having more inorganic constituents are called mineral soils. The majority of the soils of India are mineral soils. If more than 20% of constituents in soil are organic, then such soils are referred as organic soils.

5.2.3 Soil Water

The pore space of soil is occupied by water and air, their content in soil is inversely proportional to each other. Optimum content of soil water is helpful in plant growth. Soil water acts as solvent for nutrients/salt and it helps to transport nutrient from soil to plant roots.

5.2.4 Soil Air

A part of the soil pore space not occupied by soil water is filled up by air. The composition of soil air is similar to atmospheric air, *viz.* nitrogen, oxygen, carbon dioxide, inert gases and water vapour. But soil air has higher concentration of CO_2 (0.25%) than atmospheric air (0.03%). This is due to continuous respiration of plant root and soil microorganisms. Gaseous exchange process between soil air and atmospheric air ensures fresh supply of oxygen and prevent carbon dioxide toxicity in soil.

INTEXT QUESTIONS 5.1

1. Major components of soil are ……......., ……………., …………….. and ……………

2. Soils having more inorganic constituents are called

   a. Organic soil b. Mineral soil

   c. Humus soil d. None of these

Notes

3. Soil pore spaces are filled with .... and ....

5.3 SOIL HORIZONS AND PROFILE

A soil horizon is a layer of soil approximately parallel to the ground surface. It has distinct characteristics from its adjacent soil horizon. These distinct soil properties are produced by the action of soil forming process. The soil horizons tell much about the history of soil formation. Each soil has unique combination of soil horizons. In general, a soil consists of six horizons which are designated as 'O', 'A', 'E', 'B', 'C' and 'R'.

1. **O-horizon**: This is top most horizon dominated by organic matter. O-horizon is mostly found in forest areas where continuous addition of dead plant and animal occurs.

2. **A-horizon**: This horizon is found below 'O' horizon where soil mineral matter and organic matter are intimately mixed. It is also called mineral horizon.

3. **E-horizon**: It is eluvial or washed out horizon. Silicate clay, iron and aluminium present in this region are washed out from this horizon. As a result, only sand and silt particles are present here.

4. **B-horizon**: It is illuvial or washed in horizon where material washed from E horizon are deposited here. Hence it is known as zone of accumulation.

5. **C-horizon**: This horizon has been least affected by soil forming processes and lacks the properties of O/A/E/B horizon.

6. **R-layer**: This is strongly cemented bed rock. Such bed rocks may be granite, basalt, quartzite, etc. Above horizons overlie the bed rocks from which soil have been formed.

Soil profile is a vertical section of soil from ground surface to parent material or to a considered depth (1.5 m) showing various soil horizons.

INTEXT QUESTIONS 5.2

1. What is soil horizon?
2. A soil horizon dominated by organic matter is designated as

a. O horizon	b. A horizon
c. E horizon	d. C horizon

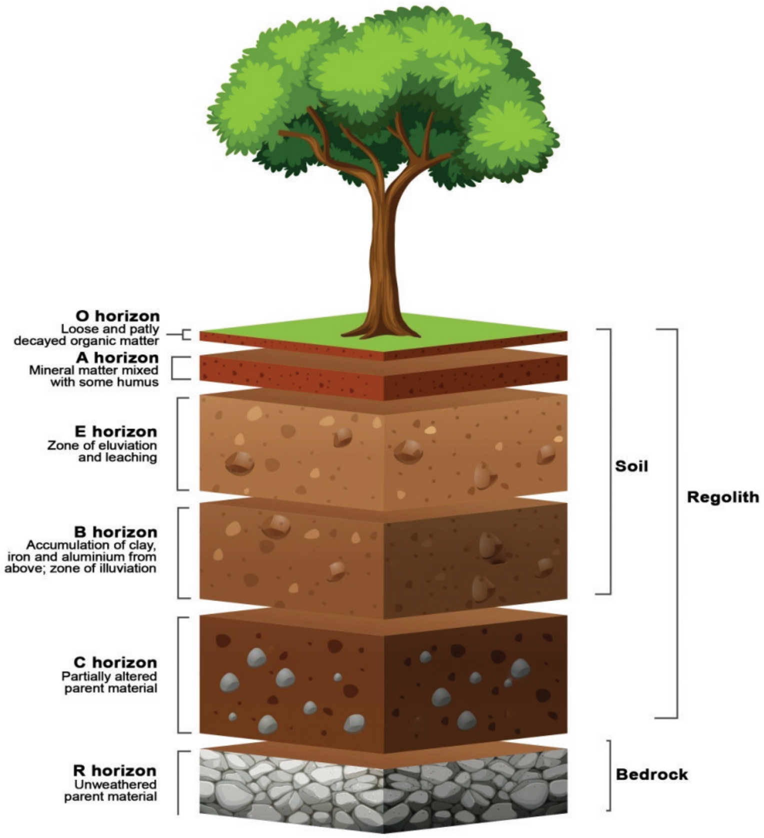

Fig. 5.2: Sequence of soil horizons

5.4 WEATHERING AND SOIL FORMATION

Soil is formed through the process of weathering. The hard consolidated rocks are transformed into soil through combined action of water, wind or organic matter decomposition. Generally, a soil is formed through two different stages

1. **1st stage:** Weathering where hard consolidated rocks are transformed into loose materials.

2. **2nd stage:** Conversion of loose materials into soil

5.4.1 Weathering

Weathering is physical disintegration and chemical decomposition of rocks and minerals. Through this process rocks are broken down into smaller fragments. Further, these small fragments undergo chemical changes to form new minerals. A weathering is of three types

A. Physical Weathering: Through this mechanical process, huge mass of rocks

are disintegrated into smaller pieces. The agents of physical weathering are temperature, wind, water, ice and pressure.

B. **Chemical Weathering**: In this process, rocks and minerals combine with water (H_2O), carbonic acid (H_2CO_3), hydroxyl ions (H^+ or OH^-) or undergo oxidation-reduction reaction. As a result, some minerals are disappeared, some are altered or new minerals are formed.

C. **Biological Weathering**: Actually, this is physical and chemical weathering caused by biological organisms. Growing plant root exert tremendous pressure on rock and widens the cracks and crevices. Plant root also releases CO_2 which combine with water to form carbonic acid. This acid then initiates the process of chemical weathering.

5.4.2 Factors of Soil Formation

At any place of the world, at least five factors work simultaneously to produce soil. These factors are soil forming factors e.g. **climate, living organisms, parent material, relief or topography** and **time**. American soil scientist H. Jenny (1941) had described how a soil is formed through interaction of soil forming factors. Therefore nature of soil is the result of collective action of these five factors. It is important to note that all of these factors work simultaneously to produce soil.

Let's discuss these factors in this section.

1) **Climate:** Climate is most influential factor of soil formation. Rainfall and temperature are major component of climate that affects physical, chemical and biological processes of profile development and soil formation. Precipitation results addition to and loss from parent materials. For every 10°C rise in temperature, the rate of biochemical reactions doubled. Thus, it accelerates decomposition of organic matter and weathering process.

2) **Parent Materials:** Parent material refers to unconsolidated material from which soil develops. Jenny defined parent materials as 'the state of soil system at time of zero soil formation'. These are formed due to the process of weathering or by transportation and deposition from other places. Physical, chemical and mineralogical characteristics of parent materials have a significant effect on soil formation. Parent material decides texture, pH, lime and salt-content and mineralogical composition of a soil.

3) **Topography:** Topography is mainly defined on the basis of elevation and slope of land surface. Topography modifies climate and vegetation, and very often, has a direct effect on soil formation. Sloping and undulating lands have very thin soil horizon. This is because most of the water is lost through runoff and lack of availability of water to pass through soil profile. Therefore, soils on flat/smooth land surface are deeper and have luxuriant vegetation as it permits more percolation, less runoff and soil erosion. In southern hemisphere, north facing slopes get more sunlight, therefore, are warmer and drier than south facing slopes. Hence, they are more productive.

4) **Living Organisms:** Living organisms are various plant and animal species present in the soil profile. Through their various activities, they help to form soil. For example, plant roots penetrate parent materials in the search of nutrients. When such roots die, they create passages for movement of water and favourable environment for other biological species. Plant roots also release CO_2 and organic acids which solubilize the minerals. Earthworms ingest the soil and excrete them in granular form. Activity of human also effects soil formation.

5) **Time/age of Soil:** The period for which the parent material is exposed to weathering is called time. In other word, it is the period from the start of soil development to present stage. Soil formation is very slow process. It takes thousands of years for development of an inch of soil. A soil body at any point of time reflects impression of soil forming factors in its profile development. Soil maturity measured in terms of profile development. Mature soil means it has a fully developed soil profile. A young soil means factors of soil formations are still operative and changing soil properties in profile, and profile development has not completed.

5.4.3 Soil Forming Processes

Soil formation leads to formation, transformation and rearrangement of soil materials in soil horizons. Soil forming processes are very complex in nature. Many dynamic chemical and biological reactions operate simultaneously during soil formation. Four basic processes that take place during soil formations are

I. **Gain** or **addition** to the soil

II. **Loss** from the soil

III. **Transformation (conversion):** Transformation takes place through chemical weathering. Here, primary minerals are converted into secondary minerals and

Notes

organic residues are transformed into humus by humification process.

IV. **Translocation (migration):** In translocation, materials like clay, organic matter or hydrous oxides are transported with water by the process of leaching, percolation or run off.

INTEXT QUESTIONS 5.3

1. Weathering is process of transforming soil into hard mass of rocks (True/False).

2. Chemical weathering occurs through

   a. Water b. Carbonic acid

   c. Hydroxyl ions d. All of these

3. Enlist the factors of soil formation.

4. The basic processes of soil formation are ………………., …………………, ……………. and ……………………

5.5 PROPERTIES OF SOIL

Soil is regarded as living material. Therefore it possesses various physical, chemical and biological properties. These properties are the result of soil forming processes. As the factors of soil formation vary from place to place, soil properties also change with them. Let's discuss some of the important soil properties in this section.

5.5.1 Physical Properties of Soil

Physical soil properties include texture, structure, density, porosity, temperature, colour and water content.

i. Soil Texture

Soil texture refers to relative proportion of sand, silt and clay in soil. It is an important soil property which gives an idea about other soil properties like water holding capacity, bulk density, and nutrient retention, etc. Texture is a permanent property of soil which can't be changed easily. Soil particles can be differentiated into various groups based on their size.

Table 5.1: Dimension/size of different soil particles

Particle group	Diameter (mm)
Clay	Less than 0.002 mm
Silt	0.002-0.02 mm
Fine sand	0.02-0.2 mm
Coarse sand	0.2-2 mm

Based on relative percentage of soil particles (sand, silt and clay), soils are classified into various textural classes. These classes are represented the through textural triangle.

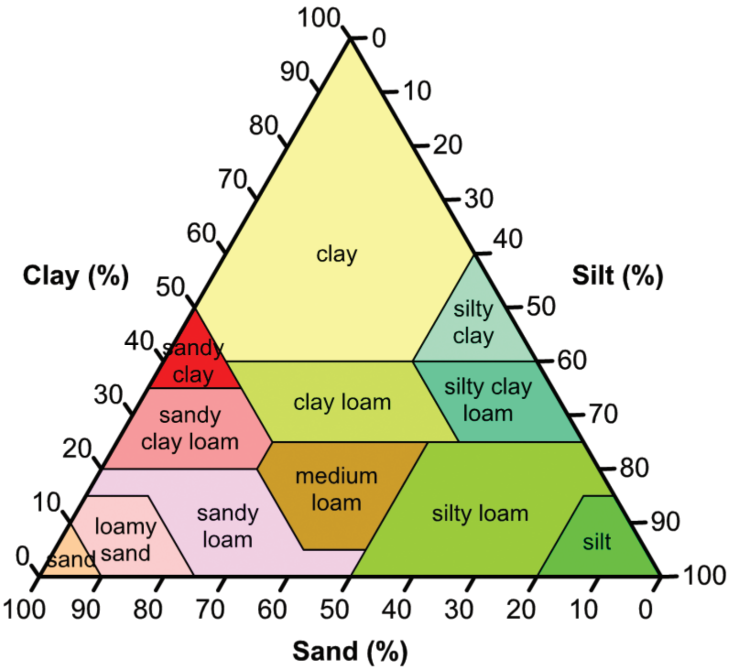

Fig. 5.3: Textural triangle

Texture of soil can be determined by laboratory methods or by feeling the soil in between thumb and forefingers. Sands feel gritty while silt feels like flour or talcum powder. Clay particle are hard when dry and exhibit stickiness when wet.

ii. Soil Structure

Under natural condition, primary soil particles (sand, silt, clay) do not exist freely. They are bonded together into aggregates through some cementing agents.

Notes

These aggregates are called secondary particles. Arrangement of primary particles and their aggregates into certain definite pattern is called soil structure. Natural aggregate of soil is called peds. Soil structures are classified into four types based on their shapes.

Table 5.2: Brief description of soil structures

Type of Structure	Description
Plate like	This structure has flattened compressed appearance. Here horizontal dimension is more developed than vertical dimension.
Prism like	The soil particles are arranged along a vertical line resembling a prism. Here vertical dimension is more developed than horizontal dimension.
Block like	Structural units appear like a block where all of the three dimensions are of about same size.
Spheroidal/sphere like	The sizes of structural units are small and spherical. They may be porous or non-porous. Porous spheroidal structure called crumb is ideal for satisfactory crop growth.

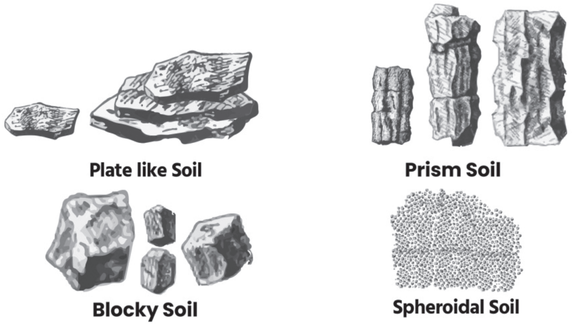

Fig. 5.4: Different types of soil structure

iii. Porosity

Porosity is the percentage of soil volume occupied by pore spaces. Pore spaces in soil are that portion of soil volume which is not occupied with soil solids (mineral matter + organic matter). Generally, an ideal soil has 50% solid space and 50% pore space. At field condition pore spaces are filled with water and air. Therefore, it indirectly affects crop growth. If good proportions of pore

Notes

spaces are not maintained in soil, plant may suffer from aeration and water availability. Two types of pore are found in soil viz. macro and micro pore.

- **Macro Pore**: These are large pores having diameter more than 0.06 mm. Water and air can easily pass through macro pores. Sandy soils have large number of macro pores.

- **Micro/capillary Pore**: They are smaller sized pore with diameter less than 0.06 mm. Micro pores play critical role in plant water availability. Generally, clay soil has greater proportion of capillary pore. However, movement of water is limited through these pores.

iv. Density

Can you recall the formula of density from your science book? It is mass per unit volume of a substance. Density of soil is expressed in gram per cubic centimeter (g/cm^3) or mega gram per cubic meter (Mg/m^3). There are two types of density of a soil a) particle density and b) bulk density.

$$Density = \frac{Mass}{Volume}$$

- **Particle Density:** As the name indicates, it is the density of soil solid (mineral matter + organic matter) only. Hence, particle density is the ratio of mass of soil solid and volume of soil solid. It is also known as true density of soil.

$$Particle\ density = \frac{Mass\ of\ soil\ solid}{Volume\ of\ soil\ solid}$$

- **Bulk Density:** In the previous section, you found that apart from solid part, soil also has substantial pore spaces. These pore spaces occupy large portion of soil volume. When we include this pore volume in calculation of density, it becomes bulk density of soil. Bulk density is defined as mass of soil solid per unit volume of soil (including pore spaces). Generally bulk density of soil is lower than particle density.

$$Bulk\ density = \frac{Mass\ of\ soil\ solid}{Volume\ of\ soil\ solid + volume\ of\ soil\ pore\ space}$$

v. Soil Water

Water is a universal solvent for all the nutrients present in soil. Several organic and inorganic substances, plant nutrients are dissolved in soil water; therefore it is called soil solution. Soil water helps plant to absorb essential nutrients from their root zone. Important physiological processes of plant and soil organisms are also controlled by soil water. Generally, water is held in between pore spaces

Notes

and on the surfaces of soil particles. Rainfall and snow fall are the major sources of soil water. After rainfall, the fate of water in soil is presented as follows

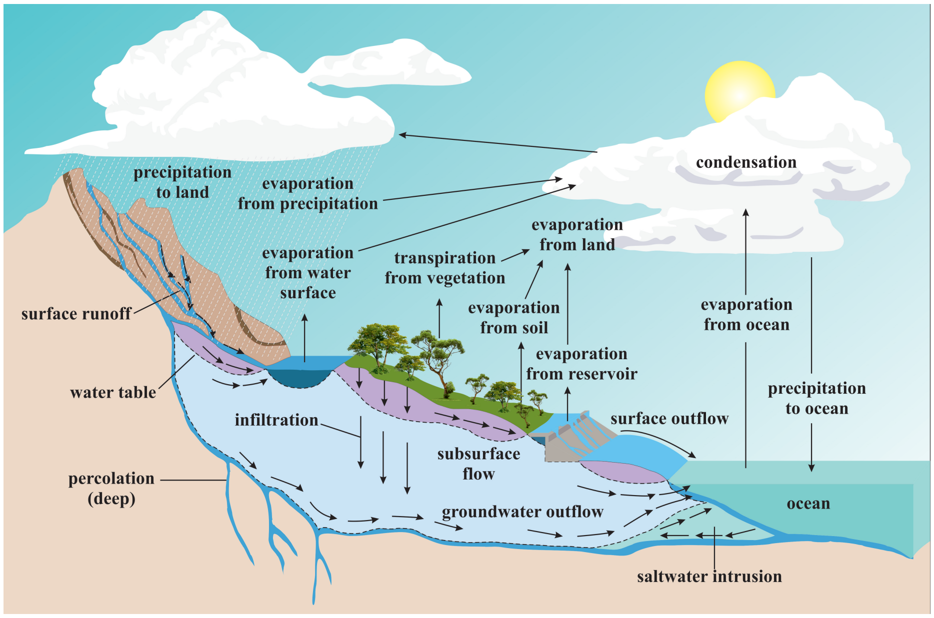

Fig. 5.5: Movement of water between soil, atmosphere and ocean

vi. Soil Colour

Colour of soil is the first criteria through which human can identify the soils. Globally, soils are found in various colours like red, yellow, brown, black or white. Colour of soil is determined by the parent material from which it develops, mineral composition, organic matter and water content. If a soil has high organic matter and water content, it is darker in colour.

vii. Soil Temperature

Optimum soil temperature is essential for seed germination, root growth and microbial activity. Solar radiation is the main source of heat energy in soil. As solar radiation cannot reach uniformly to all the places, place-to-place variations exist in soil temperature. Generally, soil temperature is highest during afternoon, while it is lowest in the morning just before the sun rise. Generally, dark coloured soil absorbs more heat and it has higher temperature than light coloured soil.

INTEXT QUESTIONS 5.4

1. The size of clay particles is

a. > 2 mm　　b. 0.002 – 0.02 mm

c. 0.02 – 0.2 mm d. < 0.002 mm

2. The relative proportion of sand, silt and clay in soil is called

   a. Soil structure b. Soil texture

   c. Soil consistency d. Soil water

3. Soil structure which is ideal for plant growth

   a. Platy b. Crumby

   c. Blocky d. Prismatic

4. Which type of soil absorbs more heat?

ACTIVITY 5.1

Collect the soil from different areas from your locality. Carefully observe whether these are same in colour or different. Add few drops of water to these soils. Describe how colour changes with addition of water.

....

....

....

5.5.2 Chemical Properties of Soil

Soils differ very much in their chemical composition due to nature of rocks from which they are formed. Moreover, different soil types have different plant nutrient availability. It is very important to know about the chemical properties of soil to successfully grow a crop. Let's discuss some of these properties in detail.

i. Soil Reaction or pH

Soil pH is a measure of acidity or alkalinity present in a soil. It is the most important chemical property of soil which governs availability of nutrients and activity of biological organisms. pH is defined as negative logarithm of hydrogen ion activity in soil solution. In other words, it is concentration of H^+ or OH^- ions in soil solution. When concentration of H^+ ion is higher that OH^- ion, then soil is called acidic and when concentration of OH^- ion is higher that H^+ ion, then soil

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is called basic/alkaline; at equal concentration of H^+ and OH^- ion, soil is said to have neutral pH. Neutral pH is considered ideal for crop cultivation as most of the nutrients are in available form in this pH range.

Generally, soil acidity or alkalinity is expressed through pH scale which extends from 0 to 14. pH 7 is considered as neutral while below 7, it is acidic and above 7, it is alkaline.

Table 5.3: pH rating of soil

Soil rating	pH range
Extremely acidic	<4.5
Very strongly acidic	4.5-5.0
Strongly acid	5.1-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3

ii. Electrical Conductivity

Electrical conductivity (EC) refers to total amount of soluble salts present in the soil solution. If a soil has higher soluble salt content, then it is said to have higher electrical conductivity and vice-versa. It is expressed as dS/m (deci Siemens per metre) or mmho/cm (milimho per centimeter). Based on pH and electrical conductivity, soils are classified into various groups.

Table 5.4: Classification of soil based pH and electrical conductivity

Soil type	pH	EC (dS/m)
Saline soil	< 8.5	> 4
Alkali soil	> 8.5	< 4
Saline-alkali soil	> 8.5	> 4

iii. Presence of Soil Colloids

Soil particles which has diameter between 1 µm to 1 nm are considered as soil colloids. Soil colloids have unique properties like large surface area, high electric

charge, cohesion and adhesion. These colloids are the most reactive part of soil. Therefore, presence of colloids in a soil imparts peculiar characteristics like high water holding capacity, greater nutrient content, better soil structure and infiltration. Colloids in soil can be classified into two types – inorganic and organic.

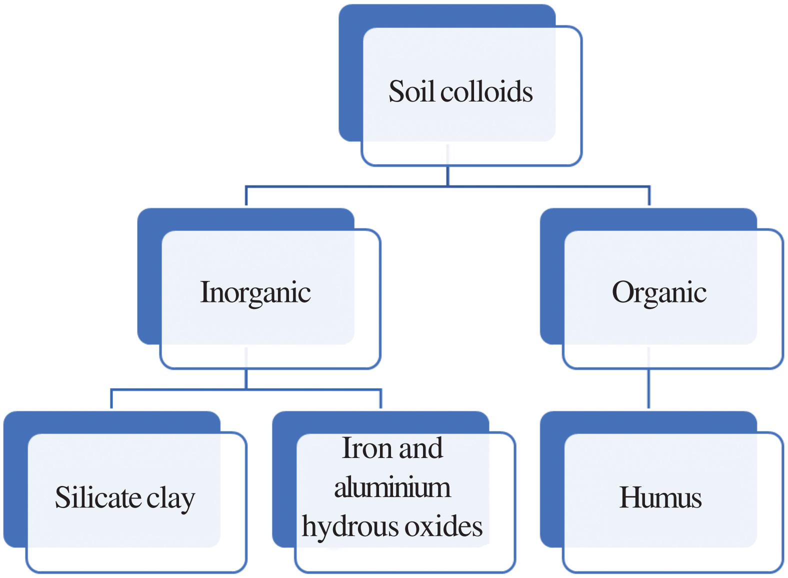

Fig. 5.6: Classification of soil colloids

Silicate clays: These are soil clay particles of colloid size dimension. Silicon is the basic structural element of these colloids. One clay particle is composed of many layers like a deck of cards. Based on arrangement of layers, silicate clays are further classified into several groups. Example of such silicate clays are Kaolinite, Montmorillonite and Illite.

iv. Soil Organic Matter

Soil organic matter consists of decomposing plant and animal residues. Additionally, it includes dead and living microbial cells along with their synthesized products. The residues of organic matter left after microbial decomposition is called humus. In nature, humus is structureless, dark brown to black materials. Organic matter is the principle source of organic carbon in a soil. These are store house of plant nutrients. They improve soil structure, aeration, biological activity and water movement in soil. Overall, organic matter improves physical, chemical and biological properties of the soil.

v. Presence of Plant Nutrients

There are seventeen (17) nutrients essential for plant growth. These nutrients

Notes

are present in soil solution. Source of these nutrients is primarily parent materials from which soil is developed. Through the process of weathering, nutrients are released from rocks and minerals and become available for plant uptake.

vi. Cation and Anion Exchange

Soil colloidal particles possess electric charge (both positive and negative charge) on their surface; however negatively charged soil colloids are dominant in soil. Plant nutrients are present in soil in cationic or anionic form. When a positively charged cation comes in contact with negatively charged clay particle, it is adsorbed on the surface of particle due to electrostatic attraction force. The phenomena of cation exchange is basically process of exchanging cation present in soil solution with those present of soil surface. Cation exchange capacity (CEC) indicates quantitative measure of soil's ability to retain cations. A soil having high organic matter content or Montmorillonite type clay mineral has high cation exchange capacity. In general, fertile soils are those soils which have higher cation exchange capacity. In similar way, anion exchange happens when negatively charged anion is attracted by positively charged clay particles.

5.5.3 Biological Properties of Soil

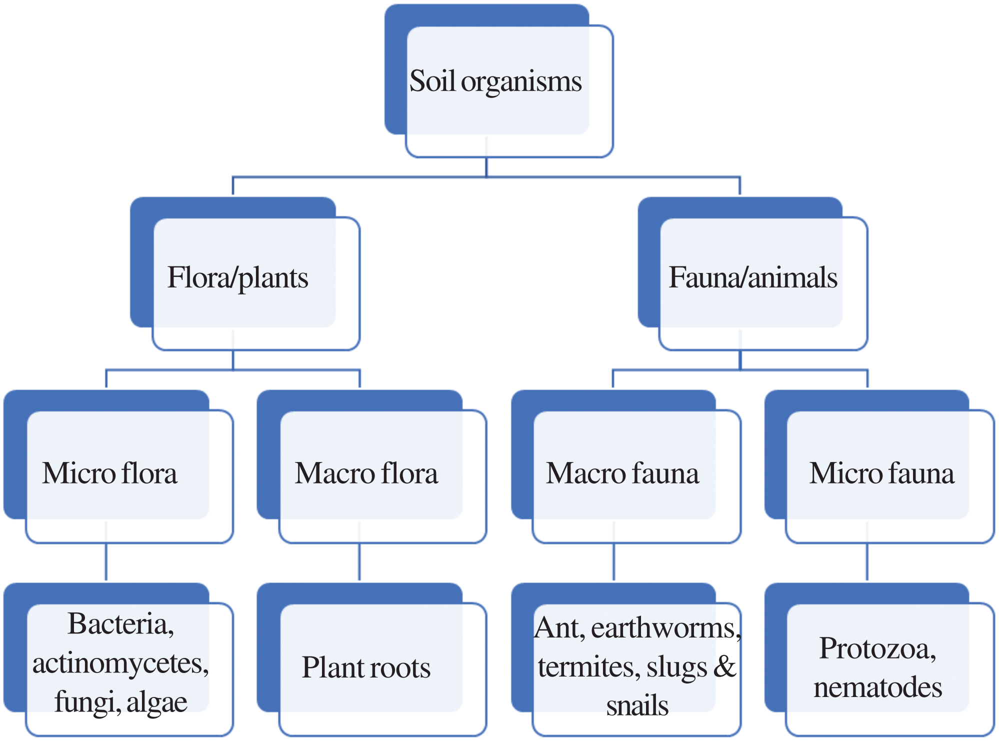

Fig. 5.7: Classification of soil organisms

A variety of organisms inhabit the soil. These organisms perform several critical functions in soil like organic matter decomposition, nitrogen fixation, nitrification, denitrification, nutrient transformation and biocontrol of plant pathogens. Soil biological properties indicate how well soil is suited as a habitat to microbes. Soil microbes are classified in following way

Functions of Soil Organisms

i. **Organic Matter Decomposition:** It is a process through which carbon present in organic matter is converted into CO_2. Microbes degrade organic matter for their own sustenance.

ii. **Mineralization:** Through this process, unavailable forms of nutrients are converted into plant available forms. For example, microbes like *Bacillus megaterium* solubilize the phosphate ions from insoluble compounds like calcium phosphates.

iii. **Nitrogen Fixation:** It is a biological process by which certain bacteria and algae convert atmospheric nitrogen (N_2) into ammonia (NH_3) with the help of enzyme nitrogenase. Legume plant has special type of bacteria (*Rhizobiun*) in their root nodule which can fix atmospheric nitrogen.

iv. **Nitrification:** It is basically mineralization process of nitrogen. Here organic nitrogenous compounds are converted into nitrate ions (NO_3^-) by nitrifying bacterias like *Nitrosomonas* and *Nitrobacter*.

v. **Denitrification:** Through this process, bacteria like *Pseudomonas*, *Bacillus* can convert ammoniacal (NH_4^+) or nitrate ions (NO_3^-) present in soil into gaseous form of nitrogen like NO, N_2O, N_2. This is a harmful process as nitrogen is lost from a soil system.

INTEXT QUESTIONS 5.5

1. When concentration of H^+ ions are higher than OH^- ions in soil solution, then soil is

a. Saline	b. Alkaline
c. Acidic	d. Neutral

Notes

2. What are soil colloids?

3. Give one example of 2:1 type clay mineral.

4. Quantitative measure of soil's ability to retain cations is called ……………………..

5. The process of converting atmospheric nitrogen into ammonia is called

   a. Nitrification b. Denitrification

   c. Nitrogen fixation d. Ammonification

5.6 SOIL FERTILITY AND PLANT NUTRITION

Nutrients are the chemical compounds required by organisms for growth and metabolism. Plant nutrients are present in soil in varying quantities. The inherent capacity of soil to provide plant nutrients in adequate amount and in a proper balance is termed as soil fertility. Therefore, a fertile soil is expected to produce abundant crop under suitable environment.

There are seventeen elements which are considered as essential for plant. Apart from them, there are other nutrients which are beneficial to selected plants only. Hence they are termed as beneficial elements. You will learn more about these nutrients in lesson 7 'Nutrient, water and weed management'. Here, we will discuss some important terms related to plant nutrition.

A. **Deficient:** When the concentration of an essential element is low enough to limit yield severely and distinct deficiency symptoms are visible, then that element is said to be deficient. Extreme deficiencies can result in plant death. With moderate or slight deficiencies, symptoms may not be visible, but yields will still be reduced.

B. **Insufficient:** When nutrient concentration in plant is below the desired level which is required for optimum yield, but distinct deficiency symptoms are not visible, the element is said to be insufficient.

C. **Sufficient:** Nutrient content at which plant produces optimum yield.

D. **Toxic:** When the concentration of essential or other elements is higher than required, then nutrient is said to be toxic. Toxic elements reduce plant growth and yield.

E. Luxury Consumption: It is a condition when a plant takes up excess amounts of nutrients beyond their sufficient concentration. At luxury consumption plant does not produce any toxicity symptoms.

F. Critical Range: The nutrient concentration in the plant below which a yield response to added nutrient occurs. Critical level or ranges vary among plants and nutrients but occur somewhere in the transition between nutrient deficiency and sufficiency.

5.6.1 Mechanisms of Nutrient Transport from Soil to Plant

A. Passive Absorption of Mineral Ions

Through this mechanism, plant cells absorb minerals without any use of metabolic energy. It may be achieved by some of physical process like diffusion, mass flow and contact exchange or root interception.

B. Active Absorption of Mineral Ions

An active absorption is a process where nutrient uptake by plant requires the use of metabolic energy. This energy is mainly derived from ATP (Adenosine triphosphate) formed during photosynthesis. Here absorption takes place against the concentration gradient.

5.6.2 Factors Affecting the Availability of Nutrients

Availability of nutrients to plant is a complex process. The various soil factors affect the plant growth in different manners. Soil pH, CEC, organic matter content, oxidized and reduced condition of soil, soil texture, structure, soil moisture content and soil composition, etc. are the major factors responsible for nutrient uptake. Although farmers are unable to manage all of these factors; however they can modify many of these factors in their advantage.

1) Soil pH

Different nutrients have different optimal pH ranges for absorption by plants. Soil acidity or alkalinity can affect the solubility and availability of certain nutrients.

2) Cation Exchange Capacity (CEC)

CEC refers to the soil's ability to hold and exchange cations (positively charged ions). Soils with higher CEC can retain more nutrients, making them available to plants over time.

3) Soil Texture

The texture of the soil (sand, silt, clay) can influence nutrient availability. Sandy soils drain quickly, which may result in leaching of nutrients, while clayey soils may retain nutrients and make them available to plant roots for longer period of time.

4) Organic Matter

The presence of organic matter in soil enhances its fertility. Organic matter contributes to nutrient retention and microbial activity, which influences the breakdown of organic materials into forms that plants can absorb.

5) Soil Moisture

Presence of sufficient moisture in soil is important for plant nutrition. If a soil is dry, there will be no water to transport nutrients from other places of soil to plant root zone. As a result plant will not get optimum amount of nutrients.

Understanding and managing these factors are essential for optimizing nutrient availability in agricultural practices. Soil testing and proper nutrient management practices can help ensure that plants receive the nutrients they need for healthy growth.

INTEXT QUESTIONS 5.6

1. How many elements are considered essential for plant growth?

2. When the concentration of an elements is high enough to reduce plant growth and yield, then element is said to be

   a. Deficient b. Sufficient

   c. Toxic d. Insufficient

3. Movement of nutrients ion form the zone of higher nutrient concentration to the zone of lower nutrient concentration is termed as

   a. Diffusion b. Mass flow

   c. Contact exchange d. Root interception

4. Soils with higher CEC retain less amount of nutrients (True/False).

5.7 SUSTAINABLE SOIL MANAGEMENT

Soil is essentially a non-renewable resource. Approximately, 400 years are required for the formation of one cm soil. If the soil is not managed properly, its performance will decline over the time. Intensive agriculture, urbanization, and climate change have negative effect on soil health. We have to use this precious natural resource carefully to meet the needs of the present without compromising the ability of future generations to meet their own needs. The sustainable soil use means using the soil in a way that builds healthy soil, reduces erosion, and minimizes the need for chemical inputs which are environmentally degrading in nature.

5.7.1 Threats to Soil Sustainability

Some agricultural practices place a significant pressure on the environment, especially soil health. The result of such pressure includes soil erosion, organic carbon loss, nutrient imbalances, multiple nutrient deficiency, acidification, soil contamination, water logging, compaction, acidification, salinization, and loss of biodiversity. Unsustainable soil management practices can release excess greenhouse gases like carbon dioxide (CO_2), methane (CH_4). It further contributes to the global warming and climate change.

1) Excessive use of agro-chemicals (fertilizer or pesticides) results in toxicity of soil. These chemicals harm microbial biodiversity present in the agro-ecosystem. Such unscientific use of synthetic chemicals also makes the ground water contaminated and the soil acidic or alkaline resulting nutrient deficiency.

2) Heavy use of agricultural machinery on soil creates tremendous pressure on soil. Subsequently, soil is compacted and plant root will not be able to penetrate.

3) Excessive tillage operation is also injurious to soil health. It destroys the soil structure and decomposes soil organic matter very rapidly.

4) If irrigation water carries excessive salts, it will make the soil saline.

5) Sometime proper drainage of water is not available on land. Then water is impounded for a longer period of time which will create anaerobic condition. Prolonged anaerobic condition kills the aerobic microorganisms.

6) Soil erosion is the removal of the upper layer of soil which is most fertile. Exposure of soil to strong winds, heavy rains, and flowing water, human activities like farming and land clearing make soil vulnerable to erosion.

7) Stubble burning is a practice of setting on fire the straw stubble (*parali*) that is left on the land after harvesting of grains of paddy. This is done with an aim of removing agricultural waste from the field and prepares the land for the next cultivation. Burning paddy straw radiates heat that kills fungus and bacteria that is essential for soil fertility. The smoke dispersed due to burning caused irritation to eyes, breathing difficulties and lung diseases.

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5.7.2 Practices for Sustainable Soil Management

Healthy soils support diverse range of organisms, as they provide sufficient nutrients, aeration and water holding capacity. Adopting sustainable agricultural practices can enhance soil carbon content and help offset greenhouse gas emissions. Traditional agricultural practices, such as crop rotation, inter cropping, mixed cropping, organic farming, and natural farming have holistically aimed at maintaining soil fertility.

a) **Integrated Nutrient Management (INM):** It is the combined application of chemical fertilizers along with organic fertilizers. Organic fertilizers include farm yard manure (FYM), compost, vermin-compost, bio-fertilizer, green-manure crop and other decomposable materials. Maintenance of soil fertility and balanced supply of plant nutrients are the major objectives of INM.

b) **Judicious use of fertilizer:** Farmers often tend to use excess amount of fertilizers for crop production. Judicious use of fertilizer means supply of all the essential nutrients as per the need of crops. Basic tip to achieve this is to follow the ‘4Rs’ principle during fertilizer application. This principle recommends to use fertilizer at

- Right time
- Right place
- Right rate
- Right source

c) **Reduced/minimum Tillage:** Reduced tillage is a common sustainable soil management technique. In this technique, only those tillage operations are performed which are absolutely necessary for crop production. This has several benefits like keeping soil structure intact, increasing organic matter and supporting microorganisms and reducing soil erosion/runoff.

d) **Use of Cover Crops:** Generally, crop fields are left empty in between crop growing seasons. Growing of cover crop during this gap period protect the soil from erosion. They recycle the nutrients present in soil which would otherwise wash off with rain during off-season period. Generally, grasses with shallow fibrous root system are preferred as cover crop. When ploughed and incorporated within soil, they act as manure for subsequent crops.

e) **Use of Green-manure Crops:** Green manure crops are those crops grown for the purpose of improving soil fertility and organic matter content. They differ from cover crops as the later is grown to protect soil only. During decomposition, green-manure provides fresh, easily decomposable organic material as a food to soil microorganisms. Consequently, soil microbial activity and physico-chemical properties are improved. In India, *Dhaincha* (*Sesbania aculeata*) and Sunhemp (*Crotolaria juncea*) are widely used as green manure crop.

f) **Better Crop Rotation:** Crop rotation is the process of changing the crops that are cultivated in a field in a specific order that varies with the growing seasons. To stop soil from being depleted and to use fewer pesticides and fertilizers, it is essential to switch to crops with different nutritional profiles and disease and insect pressures. Additionally, it can increase soil organic carbon, increase soil fertility, and improve biodiversity.

For example, you may plant legume crops after planting rice or wheat which take up lot of nutrients from soil. Legumes fix nitrogen in the soil and improve fertility.

g) **Avoid using Bad Quality Irrigation Water:** All irrigation waters contain some amount of salt. But, we should carefully choose those waters which have lower level of soluble salts to prevent the development of soil salinity. Water should also be free from any toxic metals, compounds and plant pathogens.

Therefore sustainable soil management is really necessary as everybody's life depends on healthy soil. It is the cornerstone of productive agriculture and food production.

Notes

INTEXT QUESTIONS 5.7

1. What is soil erosion?

2. Which types of crops are preferred as cover crops?

3. '4R' principle is application of fertilizers at …………, …………….., ……………. and …………..

4. Make a list of sustainable soil management practices.

Notes

ACTIVITY 5.2

You may have seen that some kitchen wastes are generated daily at your home. Often these are dumped at other place or collected by some people. You can use biodegradable wastes like left over vegetable, fruits, food materials for making organic fertilizer. This is also a way of sustainable management of resources. Follow the process given below to make your home made organic fertilizer.

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1) Dig a pit of 12-14 inches deep at your backyard or you may take a container with hole beneath it.

2) Collect the vegetable and fruit wastes from your kitchen and put them inside the pit/container.

3) Add brown materials like dried leaves, cocopeat or handful of soil.

4) You can spray some water if wastes are excessively dry.

5) You may provide microbes to these wastes for quick decomposition. For this you may add cow dung and/or earthworms.

6) To provide oxygen, you may make perforated holes in the container or churn the waste once in every four days.

Cover your pit/container appropriately so that rain water cannot enter in it. Your compost will be prepared within 2-3 weeks. Composting is like the art of cooking and is completely subjective. There is no hard and fast rule regarding the quantity of waste, dry leaves or the size of the container.

WHAT YOU HAVE LEARNT

- Soil is a 3-dimensional, polyphasic, dynamic natural body on upper portion of

the earth's crust which supports plant growth.

- An ideal soil has four components *viz*. mineral matter (45%), organic matter (5%), soil air (~25%) and soil water (~25%).
- A soil horizon is a layer of soil approximately parallel to the ground surface. The distinct properties of a soil horizon are produced by the action of soil forming process. Basic soil forming processes include gains, losses, translocation and transformation.
- Soils are formed through the process of weathering. The process of soil formation is controlled by five major factors (climate, parent material, living organisms, topography and time).
- Being a natural living body, soil has several physical (soil structure, texture, water, air, temperature, colour), chemical (pH, electrical conductivity, organic matter, soil colloids, plant nutrients) and biological (plant roots, bacteria, actinomycetes, virus, algae, fungus) properties.
- Soil fertility is defined as the inherent capacity of soil to provide nutrients and water for plant growth and development. Plants take up nutrient from soil through the process of diffusion, mass flow and contact exchange.
- Soil is the key to agriculture and food production. Soil health should be maintained by adopting sustainable management practices like integrated nutrient management (INM), careful fertilizer application, use of cover crop, green-manure crop, crop rotation, reduced tillage, etc.

TERMINAL QUESTIONS

1. What is the difference between soil horizon and soil profile? Discuss major soil horizons found in a soil profile.
2. 'Soil is a living body' – justify the statement.
3. Illustrate various types of soil structures along with their brief description.
4. Why presence of soil colloids is important for crop production?
5. Write short note on the following topics

   a. Soil porosity b. Cation exchange capacity (CEC)

   c. Soil pH d. Soil fertility
6. Do you think presence of organic matter is important for soil? Write your answer with suitable explanation.

7. Differentiate between bulk density and particle density.
8. Compare the terms ‘deficient’, ‘sufficient’, ‘toxic’ and ‘luxury consumption’.
9. Explain the mechanisms through which plant takes up nutrient from soil.
10. Suppose you are an agriculture officer in block. In your area, farmers often come to you and complain about poor yield of crops due to poor soil nutrient content. What practices would you recommend as an agriculture expert to them?

Notes

ANSWERS TO INTEXT QUESTIONS

5.1

1. Mineral matter, organic matter, soil water and soil air
2. Mineral soil (option b)
3. Water and air

5.2

1. A soil horizon is a layer of soil approximately parallel to the ground surface.
2. ‘O’ horizon

5.3

1. False
2. All of these (option d)
3. Climate, parent material, organisms, time, topography
4. Gain, loss, transformation, translocation

5.4

1. < 0.002 mm (option d)
2. Soil texture (option b)
3. Crumby (option b)
4. Dark coloured soil

5.5

1. Acidic (option c)
2. Soil particles having diameter between 1 μm to 1 nm are called soil colloids.

3. Montmorillonite
4. Cation exchange capacity
5. Nitrogen fixation (option c)

5.6

1. 17
2. Toxic (option c)
3. Diffusion (option a)
4. False

5.7

1. Soil erosion is the removal of the upper layer of soil
2. Shallow rooted grass species
3. Right time, right place, right rate, right source
4. Integrated nutrient management (INM), judicious use of fertilizers, use of cover crop, green manure crop, crop rotation, reduced tillage

GLOSSARY

Aerobic and anaerobic condition: When oxygen is present in environment, then condition is called aerobic. If O_2 is not present, then condition is anaerobic.

Mineral: Mineral is an inorganic body, produced by the process of nature, usually having a definite chemical composition. It will have crystalline structure if they are formed under favourable condition,

Rocks: Rocks are basically aggregation of several minerals.

Tillage: Tillage is a mechanical process that prepares soil for planting and cultivation. It involves digging, stirring, and overturning the soil to achieve a desired condition.

SUGGESTED READINGS

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3. *Soil Science: An Introduction*, (2015). Indian Society of Soil Science, New Delhi.
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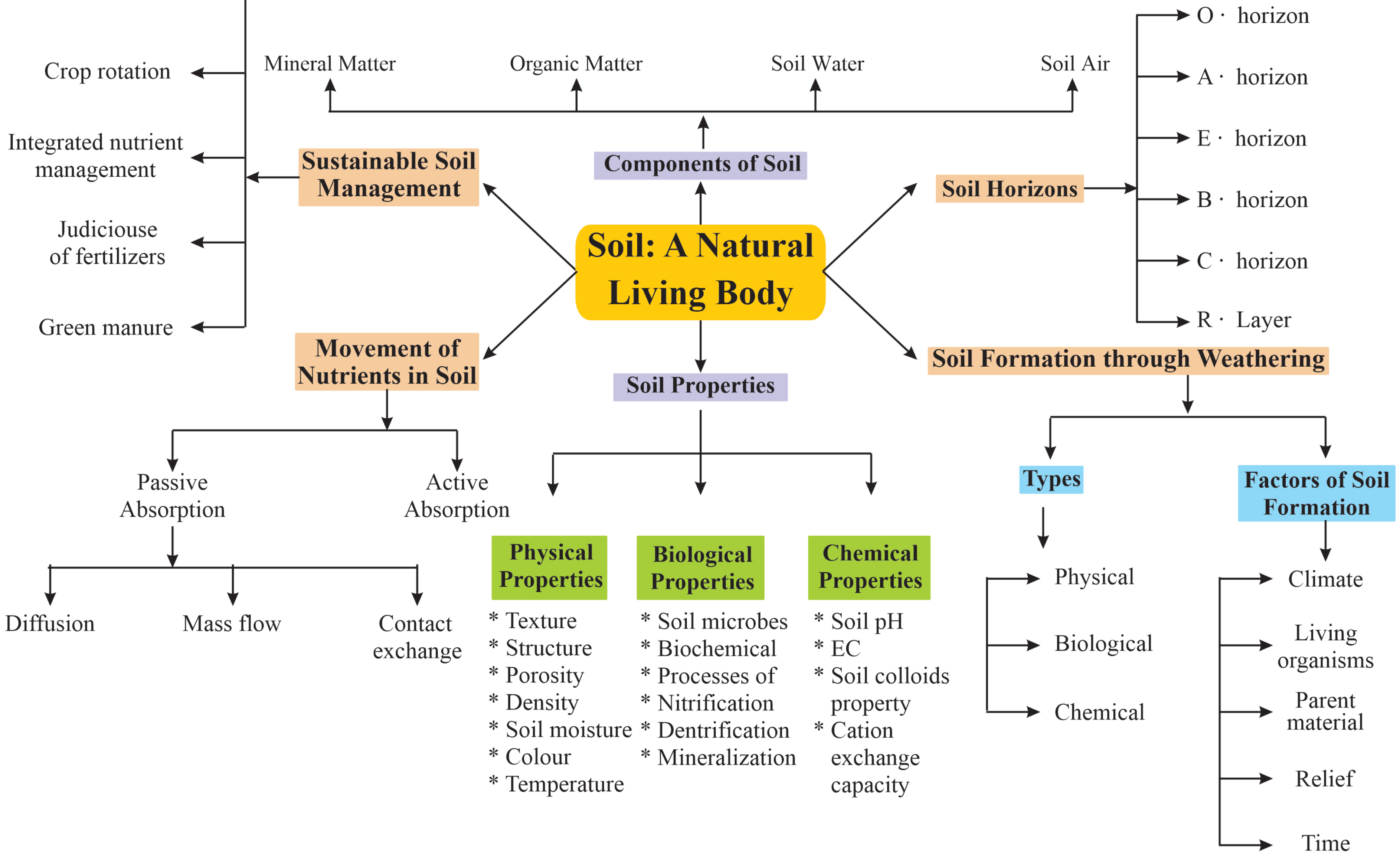
WHAT YOU HAVE LEARNT



NOTE

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CROPS, CROPPING SYSTEM AND CROP ESTABLISHMENT

In the previous lesson, we have discussed the basics of soil science. Every living organism on this planet needs food to stay alive and to continue all other essential life processes. Conventionally these foods are obtained from crop plants. Crop production practices are crucial for ensuring food security and efficient agricultural system. These practices encompass a range of activities involved in growing and managing crops. In this lesson, we will learn about some of these activities.

LEARNING OUTCOMES

After studying this chapter, the learner:

- classifies the crops growing in their surroundings following suitable criteria;
- develops integrated farming system plan for better farm productivity;
- recommends the crops for cultivation as per their specific soil and climatic requirement; and
- prepares the field scientifically for sowing and transplanting of crops.

6.1 WHAT ARE CROP PRODUCTION PRACTICES?

Let's discuss about the concept of crop production practices. Plants are the main source of food on which both humans and animals depend. These plants of known economic values when grown in community with specific purposes are called as crops. Since beginning of civilization, agriculture has been practised by people to meet the food requirement of family. It is considered as subsistence farming. On the other hand, commercialisation of agriculture started with the growing demand for food and advancement in agricultural science. It necessitated creation of crop production as a

Notes

branch of agriculture to deal with the production and management of crops for food and fibre.

Crop production practices comprise a set of practices followed by farmers starting from selection of variety till harvest of crop. These practices are land preparation, sowing, transplanting, nutrient management, weed management, water management, pest management and harvesting. To ensure optimum crop productivity, cultivation practices need to be adopted as per the principles of crop production. Climate, soil and water available in the area have profound role in deciding production potential of a crop. To realise the yield potential of crops, the management practices can be manipulated to provide a favourable condition for growth of plants.

6.2 CLASSIFICATION OF CROPS

Crops have been classified based on various criteria for better understanding the crops vis-à-vis growing season, climate, soil and water, economic importance etc.

6.2.1 Based on Growing Seasons

Each crop has specific climatic requirement which must be met for growing the crop successfully. Air temperature, relative humidity and day length are important parameters which decide the crop performances.

I. **Kharif Crops:** These crops are grown in monsoon season i.e. June-October/November which require warm, wet weather and short day length during their major growing period. In India, these crops are mostly cultivated utilizing rain water as source of irrigation. Example – rice, maize, jowar, bajra, greengram, blackgram, redgram, cotton etc.

II. **Rabi Crops** are grown during winter months i.e. October/November to mid-April. Cold and dry weather with long day condition is required by these crops. Example – wheat, gram, mustard, lentil, field pea.

III. **Zaid Crops:** Certain crops require warm and dry weather with long day condition which are prevalent during mid-April to mid-June are called *Zaid* crops or summer crops. For example, sunflower, greengram, summer rice, pumpkin, etc.

In some regions of the country, no such distinct seasons are there rather, particularly in areas where temperature fluctuations are not that wide. Under such areas, farmers have their own classification of seasons.

6.2.2 Based on Use /Agronomic Classification

A. **Grain Crops:** These crops are the cultivated grasses grown for their edible starchy grains. Such large grained crops used as staple food are **cereals**, e.g. rice, wheat, maize, barley, whereas **millets** are the small grained cereals which are grown by farmers with minor importance as food crops. Millets are more nutritious than the stable food crops for which they are also called **nutri-cereals**. Under changing climatic situations, millets are considered as resilient crops and are suitable for rainfed and drier regions e.g. Finger millet, pearl millet, little millet, kodo millet etc.

B. **Pulse Crops:** Pulses are the legume crops whose seeds are used as food especially for making *dal* by splitting the seeds. Pulse crops being legumes have gained importance as they improve soil fertility. The grains are also rich in protein for which pulses are included as key food ingredient in Indian diet, e.g. green gram, blackgram, pigeon pea, chickpea, cowpea, etc.

C. **Oil Seeds Crops:** Those crops whose seeds are rich in fatty acids and are cultivated for production of vegetable oil. Those are suitable for human consumption, are edible oilseed crops, e.g. ground nut, mustard, sesame, soybean, sunflower, safflower. Other crops like linseed and castor are non-edible oilseeds which have industrial and medicinal values.

D. **Forage/ fodder Crops:** A group of crops whose vegetative parts, either fresh or preserved are used as animal feed. When fed to milch animals they increase milk yield and reduce the cost of feeding. Fodder crops are fed to animals in different forms such as hay, silage, green fodder, pasturage, e.g. Hybrid Nappier grass, fodder maize, fodder sorghum, fodder bajra, guinea grass, berseem, cowpea, lucerne etc.

E. **Fibre Crops:** Crops which are grown for producing fibres as used in preparation of garments, bags, crafts and other useful items. Depending upon the plant parts from which fibre is obtained, there are different types of fibre crops, e.g. seed fibre (cotton), stem fibre (jute, mesta, sunhemp) and leaf fibre (agave, pineapple).

F. **Sugar Crops:** These crops are cultivated for production of sugar, e.g. sugarcane and sugar beet. Juice is extracted from sugarcane stems (called cane) used for jaggery or sugar production. By-products of sugar industry have economic uses e.g. molasses used for alcohol and yeast formation, bagasse for paper making and press mud used as soil amendment. In sugar beet, tubers are used for extraction of sugar.

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G. Root Crops: These are the crops where roots are the economic produce, e.g. sweet potato, sugar beet, carrot, turnip, etc.

H. Spices and Condiments: These crop plants or their products are used to add flavour, taste and/or color the prepared food items, e.g. ginger, garlic, chilli, cumin, onion, coriander, cardamom, pepper, turmeric etc.

I. Vegetables Crops: These are crops grown to harvest their fruits, roots or leaves afresh for human consumption. It forms an important component of vegetarian diet, e.g. brinjal, tomato, potato, okra, spinach, amaranthus, etc.

J. Green Manure Crops: These crops are grown only to increase fertility of soil, not for economic harvest. Green leaves or whole plant in vegetative stage is incorporated into the soil to add organic matter after decomposition, e.g. dhaincha, sunnhemp.

Fig. 6.1: Sesbania *green manuring*

K. Medicinal Crops: Plant parts of these crops are used in preparation of medicines, e.g. opium poppy, senna, tobacco, Japanese mint, and peppermint, etc.

L. Beverages: Crops are used for preparation of mild, agreeable and simulating drinks, e.g. tea, coffee, cocoa etc. These are also called as plantation crops.

Notes

Table 6.1: Popular field crops cultivated in India

Crop	Family	Scientific name	Major growing states
Rice	Poaceae	*Oryza sativa*	West Bengal, Uttar Pradesh, Punjab
Wheat	Poaceae	*Triticum aestivum*	Uttar Pradesh, Madhya Pradesh, Punjab
Maize	Poaceae	*Zea mays*	Andhra Pradesh, Karnataka, Rajasthan
Barley	Poaceae	*Hordeum vulgare*	Uttar Pradesh, Rajasthan, Madhya Pradesh
Oat	Poaceae	*Avena sativa*	Uttar Pradesh, Madhya Pradesh, Haryana
Sorghum/ Jowar	Poaceae	*Sorghum bicolour*	Karnataka, Maharashtra, Andhra Pradesh
Pearl Millet/ Bajra	Poaceae	*Pennisetum glaucum*	Rajasthan, Maharashtra, Gujrat
Finger Millet/ Ragi	Poaceae	*Eleusine coracana*	Karnataka, Tamil Nadu, Uttarakhand
Sugarcane	Poaceae	*Saccharum* Spp.	Uttar Pradesh, Maharashtra, Karnataka
Chick Pea	Leguminoaceae	*Cicer arietinum*	Maharashtra, Madhya Pradesh, Rajasthan
Pigeon Pea	Leguminoaceae	*Cajanus cajan*	Maharashtra, Karnataka, Andhra Pradesh
Lentil	Leguminoaceae	*Lens culinaris*	Madhya Pradesh, Uttar Pradesh, Bihar
Green gram	Leguminoaceae	*Vigna radiata*	Maharashtra, Andhra Pradesh, Madhya Pradesh

Crop	Family	Scientific name	Major growing states
Black gram	Leguminoaceae	*Vigna mungo*	Madhya Pradesh, Uttar Pradesh, Andhra Pradesh
Ground nut	Leguminoaceae	*Arachis hypogaea*	Gujarat, Andhra Pradesh, Tamil Nadu
Soybean	Leguminoaceae	*Glycine max*	Madhya Pradesh, Rajasthan, Andhra Pradesh
Mustard	Cruciferae	*Brassica* Spp.	Rajasthan, Uttar Pradesh, Haryana
Cotton	Malvaceae	*Gossypium* Spp.	Maharashtra, Gujarat, Telengana
Tobacco	Solanaceae	*Nicotiana tabacum*	Andhra Pradesh, Telengana, Gujarat
Jute	Malvaceae	*Corchorus capsularis* and *C. olitorius*	West Bengal, Assam, Bihar

INTEXT QUESTIONS 6.1

1. How many types of crops are classified based on growing season?
2. Rice is a .... season crop.
3. Give any two examples of pulse crop.
4. Which of the following is a green manure crop
   a. Rice
   b. Sugarcane
   c. Dhaincha
   d. Tobacco
5. Millets are also known as........................

6.3 CROPPING SYSTEM AND FARMING SYSTEM

Imagine a farmer who is adopting farming practices. Is he practising a single enterprise or a combination of multiple enterprises? The choice of enterprises, whether crops or any other allied enterprises, depends upon the resources available, prevailing climate, market and skill of the farmer. Growing of crop(s) on the same available piece of land in a year are expressed by different terminologies such as cropping pattern, cropping sequence, cropping system etc.

Mono cropping the same land may be occupied by one crop during one year, or with two crops (**double cropping**) in a year in sequence (**sequential cropping** or **crop rotation**), or with more than two crops in a year (**multiple cropping**). In many parts of eastern India, rice is grown during *kharif* season and the land remains fallow during dry season due to lack of irrigation and social constraints. It is a typical example of rice mono cropping system. With available irrigation rice-pulses/oilseed cropping pattern is practised by farmer which is a double cropping pattern. Rice-wheat-greengram cropping system is an example of multiple cropping in which a short duration greengram crop is fitted utilising available time between harvest of wheat and sowing of rice. Above discussion implies that, **cropping pattern** is the sequence of crops and fallow adopted in a year and their spatial arrangement on a given piece of land. Spatial intensification happens through **intercropping** wherein two or more crops are grown together on same area following definite planting geometry, e.g. maize + cowpea, wheat + chickpea, pigeon pea + ground nut, and cotton + blackgram, etc.

Cropping system and cropping pattern are used interchangeably to denote different crops grown with reference to their temporal and spatial allocation on a same piece of land in a year. However, **cropping system** considers the interaction of the existing cropping pattern with other enterprises, farm resources and used technology which determines their makeup.

6.3.1 Intercropping System for Cropping Intensification

Intercropping system is advisable in rainfed areas of dry, humid and semi-arid tropics where two or more crops can be grown simultaneously on the same piece of land. It ensures efficient utilization of inter-row space and higher productivity. Under adverse climatic conditions it insures against total crop failure. The crop of primary importance is taken as main crop and other crops in the system are included as intercrops. For example, in maize + cowpea system maize is the main crop and cowpea is the intercrop.

Certain criteria are followed while selecting the intercrops which are:

i. Intercrop should mature earlier than the main crop, e.g. pigeon pea+ground nut.

ii. Peak growing periods of both the crops should not coincide.

iii. Intercultural requirements of both crops should be similar.

iv. Crops should not be competitive rather complementary to each other both below and above ground.

Fig. 6.2: Intercropping of Coconut with Marigold

Notes

6.3.2 Relay Cropping for Intensification

Sowing of a second crop in a standing main crop just before its harvest so that there is overlapping of a part of life stages of each crop is called relay cropping or ***paira/ utera* cropping**. Relay cropping is the best way to utilise the left over residual soil moisture after a rainfed *kharif* crop. It is commonly followed in shallow low land and lowland rice ecology, e.g. rice-blackgram, rice-chickpea, rice-lathyrus, rice-linseed, rice-berseem and rice-lentil, etc. Vast rice fallow areas can be brought under cropping through promotion of relay cropping with right selection of crops and suitable varieties.

INTEXT QUESTIONS 6.2

1. When same land is occupied by more than two crop in a year, it is known as

    a. Double cropping b. Multiple cropping

    c. Mono cropping d. Sequential cropping

2. What is intercropping?

3. State two examples of *rabi* season based cropping systems.

4. Relay cropping is also known as *paira* cropping. (True/False)

6.3.3 Farming System

No single farm enterprise is likely to support the small and marginal farmers for generation of adequate income and gainful employment year round. Traditionally farmers take a combination of few enterprises, e.g. rice, dairy, poultry to meet the family needs. The scope for enhancement of income from crop production activities are limited, however, fishery, horticulture and animal husbandry sectors have tremendous potential. Government of India strategized to double the farmers' income within a short period of 6 years in which farming system approach had been emphasized. Looking at the predominance of small and marginal farmers with limited resources, Integrated Farming System (IFS) approach can enhance farm income in a viable and sustainable manner.

Integrated farming system (IFS) is a sustainable agricultural system that integrates livestock, crop production, fish, poultry, tree crops, plantation crops and other systems that benefit each other. It looks at the whole farm as a system and how different components work together to enhance ecosystem functions of the land at local and possibly landscape levels. It is based on the concept that 'there is no waste' and 'waste is only a misplaced resource' which means waste from one component becomes an input for another part of the system. The entire philosophy of farming system revolves around better utilization of time, money, resources and family labour. The farm family gets scope for gainful employment round the year.

Goals of Integrated Farming System

- Enhancing productivity per unit area
- Proper waste management through recycling
- Income generation round the year
- Employment generation and engagement of family labour
- Soil health management

Notes

6.3.3.1 Components of Farming System

Integrated farming can have many variants comprising of components chosen according to available resources on the farm, soil and climate condition, scope of recycling of byproducts and profitability of the system. Major components of IFS are,

A. **Agriculture:** Cereals, pulses, oilseeds, millets, fiber crops, sugar crops, fodder crops

B. **Horticulture:** Vegetable crops, fruit crops, ornamental crops

C. **Fishery:** Fish production, fingerling and yearling production, ornamental fish, prawn

D. **Livestock:** Dairy, goatery, poultry, piggery, duckery etc.

E. **Allied sectors**: Bee keeping, sericulture, mushroom production, vermin composting, azolla production, value additions etc.

Let us examine few complementary components and observe how resources are recycled among them in farming systems.

- **Fish-duck Integration:** Duck farming integrates well with fish farming wherein with a little additional investment ducks can enhance farmers' income. Ducks add manure in fish pond and act as aerator as required for growth of fishes. Pond surface water is utilized for free ranging of ducks who feed on aquatic weeds in pond.

- **Rice-mushroom- vermicompost:** Paddy straw which is otherwise underutilized can find its best value when used for mushroom production. After harvest of mushroom the spent substrates can be recycled for taking up vermicompost production. Vermicompost is well-known good quality compost for improving plant growth and soil health.

- **Fish-vegetable/fruits:** In high rainfall and lowland ecosystems fish production is a remunerative enterprise. Pond based farming system models in those areas incorporate vegetable and fruit crop as a complementary component which are grown on pond dykes.

INTEXT QUESTIONS 6.3

1. What is the full form of IFS?

2. To double farmer's income, Government of India emphasized.............. approach.

3. What are the components of farming system?

ACTIVITY 6.1

Assume that you are a farmer in an area facing various challenges such as declining soil fertility, water scarcity, and fluctuating market prices for crops. Propose an Integrated Farming System plan for your farm. Also highlight how this system can contribute to improve farm productivity and improve your income.

....

....

....

6.4 SOIL AND CLIMATIC REQUIREMENT

Can any crop be successfully grown anywhere? It is not possible because the local climate is the basis for crop growth and development. Crops are selected for the areas to which they are adapted. Climate of a place characterized by temperature, relative humidity, rainfall and day length has profound role in deciding potential productivity of any crop.

Type and nature of soil too decide the type of crops suitable for cultivation in an area. A particular soil is suitable for growing few crops, in other words, all crops are not suitable to grow in all types of soils. Physical characteristics of soil such as soil texture, structure, porosity and water holding capacity, chemical properties like soil reaction (acidity, salinity, alkalinity), soil organic matter, nutrient availability status, cation exchange capacity and biological properties *viz.* beneficial activities of soil microorganisms are important considerations for selection of crops. Crop management practices should aim at modifying the properties of soil to provide favourable condition for crop growth and realization of their potential yield.

Notes

Table 6.2 Soil and climatic requirement of important field crops

Crop	Soil requirement	Climatic requirement
Rice	Rice is grown in all types of soil. Soils with high water holding capacity such as heavy soils (clay, clay loam and loamy) are suitable. Neutral soil pH is needed; however, it is grown normally with soil pH between 5 to 8.	Cultivated in varying climatic conditions. Warm and humid climate with temperature from 21^0C to 37^0C is desirable during crop growth stages. Rice is a short day plant which restricts its cultivation in *kharif* season but with development of photo insensitive varieties it is grown in *rabi* and summer seasons too.
Wheat	Well drained loam and clayey loam soils are best for wheat. *Durum* wheat requires heavy soils whereas *Aestivum* type can be grown in all types of soils.	Wheat has narrower adaptability than rice with respect to temperature and moisture variations. Cool and moist weather during vegetative growth period and warm-dry weather during grain formation are ideal conditions. Optimum temperature for wheat growth is 20-25^0C.
Maize	Deep, well drained and medium textured sandy loam to clayey loam soil with a high water holding capacity is suitable for maize. Optimum soil pH varies from 5.5 to 7.5. The crop cannot tolerate water logging condition.	Maize is a warm weather plant but can be grown under diverse conditions due to its wide adaptability. It is grown from sea level up to 3000 m above mean sea level. Optimum temperatures for germination and growth stages are 21^0C and 32^0C, respectively.
Sorghum	Grown over a variety of soils but the clayey loam soil is found to be the most ideal.	It can be successfully grown under temperature ranging between 15^0C to 40^0C. It is a drought tolerant crop and can perform well under dry land condition.

Crop	Soil requirement	Climatic requirement
Pearl millet	Light textured soils with good drainage are the best soil for the crop. However, it is grown in a variety of soils, such as sandy loams (U.P, Punjab, Rajasthan), heavy clay, black soils (A.P, Tamil Nadu)	A warm weather crop which has wider adaptability to grow under different day length and temperature conditions.
Finger millet	Grown in plains and hill slopes	It is chiefly a *kharif* crop; however, it can be cultivated in some part of country round the year due to its photo and thermo-insensitivity.
Greengram	Grown in variety of soils, ranging from sandy loam to heavy loam. However, deep, well drained loam soils are ideal for crop growth.	Being tropical crop it cannot tolerate low temperature. It can be grown in *kharif*, spring and summer seasons. It can tolerate drought during *kharif* but cultivated with irrigation in spring and summer seasons.
Blackgram	Blackgram requires heavy soils, well drained with high water holding capacity. Deep loam soils free from salinity are ideal.	It is grown in *kharif*, *rabi* and summer seasons. It is drought tolerant for which it is preferred under rice fallow.
Redgram	Sandy loam to clayey loam soils is ideal, however, crop is grown in a wide variety of soils. Soil should be deep, well drained and neutral in soil reaction.	Needs warm, tropical and sub-tropical climate, fairly moist, bright sunny weather for fruit setting, susceptible to frost at flowering. Requires temperature ranging from 20^0C to 40^0C.
Gram / chickpea	It is grown in all types of soils, viz. light loam to heavy clay without salinity and sodicity. Also in soils with an efficient	A winter season crop in India, grows well in humid, arid and semi-arid conditions, cannot tolerate severe cold and frost.

Notes

Notes

Crop	Soil requirement	Climatic requirement
	drainage and free from soluble salts.	Frost at flowering damages the crop and destroys the seeds inside pod. Optimum temperature for its growth ranges from 15^0C to 25^0C.
Groundnut	As pod development happens underground, it requires a light textured soil. The crop grows best on sandy loam and loamy soils. Heavy clayey soils are unsuitable for groundnut cultivation.	It is a tropical crop requiring warm growing season with bright sunshine. High rainfall, drought and cold weathers are detrimental for crop growth. Optimum temperature for growth is 21-26^0C.
Soybean	Best soil is sandy loam with good organic matter content with a normal soil pH of 7. It is grown on wide variety of soils including black cotton soil of M.P.	The crop needs warm and moist climate, grows well in a temperature range of 15-30^0C. It can be grown in *kharif*, spring and summer seasons. Cold temperature during fruit setting lowers the oil content in seeds.
Rapeseed and mustard	Rapeseed and mustard thrive best in medium to heavy loam soils with pH of 7, however, taramira prefers light textured soils. Waterlogging is harmful for these crops.	These crops need cool and dry weather with bright sunshine. Grown during winter in India requiring about 18-25^0C temperature, low humidity and with no rain particularly at flowering stage.
Sugarcane	Heavy soil and light textured soils with high water retention capacity, high organic matter content are suitable for this crop.	The crop performs its best in tropical region receiving rainfall of 750 to 1200 mm. It can also be grown in sub-tropical regions. Optimum temperature for bud sprouting is 21-25^0C and for tillering it is 30-35^0C.

INTEXT QUESTIONS 6.4

1. Which crop is ideal for cultivation in soil with high water holding capacity?

2. Wheat requires..................... weather during vegetative growth and .... weather during grain formation stage.

3. Optimum temperature of germination of maize crop is...................

4. Which type of soil is ideal for pod development of ground nut?

5. .... is harmful for rapeseed and mustard.

6.5 CROP ESTABLISHMENT

Land is the unit where farmers grow crops. The land must be prepared well to provide a good seed bed. In a cropped land the soil becomes hard at harvest of the crop. To take up sowing of subsequent crops, the soil must be loosened for which farmers plough the field.

A sequence of operations is followed while growing field crops that usually starting from land preparation to harvest of the crop. Two stages, land preparation followed by planting are known as crop establishment.

Land preparation → Seeding/ planting → Nutrient Management → Crop protection → Harvest

Loosening the soil, cleaning field and levelling are required conditions for a well prepared seed bed. Seed bed facilitates seed germination, root penetration, aeration to rhizosphere zone, ease of intercultural operations and proper distribution of water and applied nutrients in field leading to a good crop. It is ensured by tillage operations.

6.5.1 Tillage

Tillage refers to manual or mechanical manipulation of soil to provide an ideal medium for crop establishment and growth. The word tillage has originated from Anglo-Saxon words *tilian* and *teolian*, meaning 'to plough, to cultivate soil to sow seeds and raise crops'.

More emphasis on tillage was given by **Jethro Tull** in England, who is considered as the Father of Tillage. He suggested that, ploughing is necessary to break soil in to fine

soil particles as required for plant growth. In his book 'Horse Hoeing Husbandry', he introduced horse drawn tools and drills for undertaking sowing of seeds.

Purposes of Tillage

Tillage is carried out with several purposes, the major ones are

(i) **Seed Bed Preparation:** Seed must make good contact with soil in order to absorb soil moisture for good germination. Extent of tilth required for seed bed depends up on the size of seeds. Small seeded crops need fine tilth and bold seeded ones require, coarse tilth. Raised beds, ridge and furrow, broad beds and other land shaping required for planting different crops are made through tillage only.

Tilth: Tilth refers to the physical condition of soil in relation to its friability, ease of tillage and suitability for planting while growing a crop. Soils with good tilth are described as being crumb-like, easy to slice and spongy nature brought by tillage.

(ii) **Weed Control:** Unwanted plants are to be removed before sowing of crop and during growth stages through different types of tillage operation.

(iii) **Improvement of Physical Condition of Soil:** Movement of farm vehicles, implements, humans and animals make the soil compact. Puddling operation carried out in rice crop creates impervious soil layer called hard pan which need to be broken by tillage. Root growth will be hampered by presence of hard pan in unploughed field.

(iv) **Land Levelling:** A well levelled land can produce good crops as it ensures uniform crop stand, efficient use of water and nutrient, management of weeds etc. Tillage is required to level the land.

(v) **Soil and Water Conservation:** High velocity run-off water causes soil erosion which can be slowed down by creating rough surface through tillage. When compact soil is ploughed it allows higher infiltration, storage of rain water and conserving it *in-situ* for future use.

6.5.2 Tillage Systems

Tillage systems describe the nature and sequence of tillage operations used in preparing a seed bed for planting. According to the degree of soil stirring, tillage is classified into two groups, conventional tillage and conservation tillage.

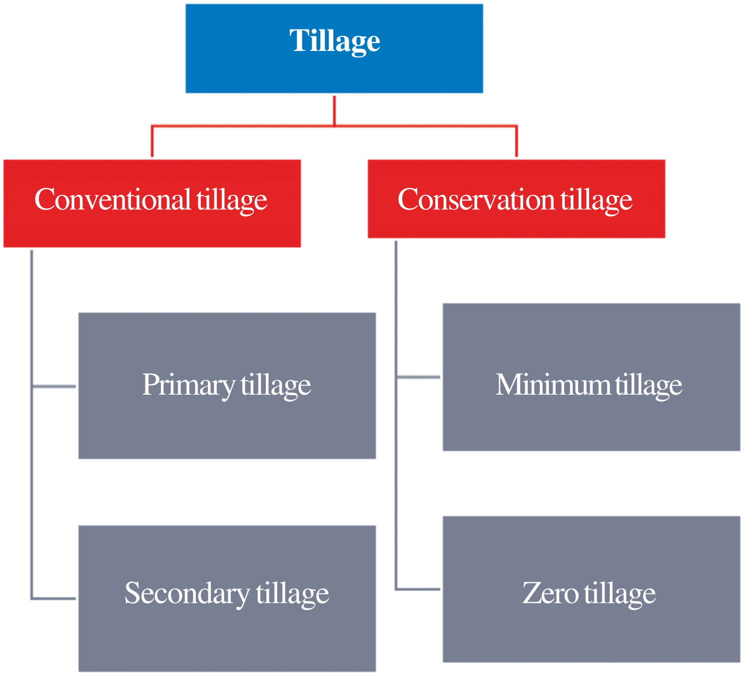

Fig. 6.3: Classification of tillage

Conventional Tillage

Conventionally farmers plough the entire field to the maximum extent using various kinds of implements. Conventional tillage is achieved by a sequence of operations starting from ploughing down the untilled compact soil until preparation of desired tilth. At each step, different tillage implements are used. Two types of conventional tillage operations as carried out are, primary tillage and secondary tillage.

1. Primary Tillage

It is the first tillage operation performed before cultivation of crops. Operations performed under this tillage system include breaking of compact top soil, inversion of soil and burying of weeds during the process. The term ploughing as commonly used refers to this primary tillage where soil is tilled to a depth of 15-30 cm.

Time of tillage is governed by soil moisture content and time of sowing of the crop. If the soil is too dry it requires more power to break the soil and large sized clods are formed. If land is ploughed under wet conditions, the soil sticks to plough, soil structure is damaged and clods on drying become very hard.

Crops with fibrous root systems (rice, wheat, maize) require shallow-deep tillage up to 15 cm depth and deep tillage up to 30cm is given to crops with tap root system (arhar, chickpea, brinjal). The deep tillage is recommended even in shallow rooted crops once in 3-4 years.

Notes

Primary tillage implements are mouldboard plough, disc plough, chisel plough, country/ indigenous (desi) plough, and power rotary tiller, etc.

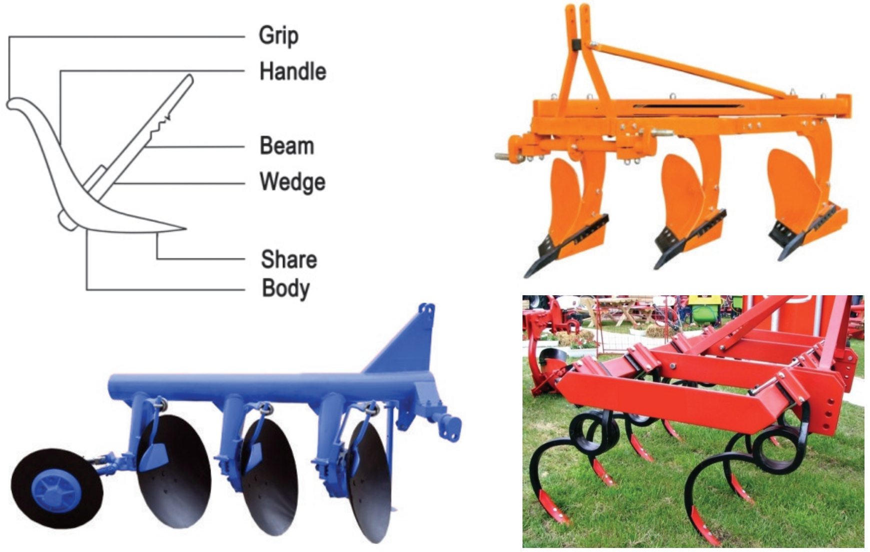

Fig. 6.4: Different types of plough a) country plough b) mouldboard plough c) disc plough d) chisel plough

2. Secondary Tillage

Tillage operations which are carried out after primary tillage to produce finer tilth for seeding is secondary tillage. It is performed with various objectives such as reducing clod size, weed control, incorporation of fertilizers, puddling and leveling soil surface. Secondary tillage is done to a shallower depth, i.e. 5-15 cm. Normally 2-3 secondary tillage operations are done after primary tillage and before planting; but this depends on the size of clods, weed density, the need to incorporate fertilizer and the need for puddling.

Based on purpose, different tillage implements are used like cultivator, harrows, rotavator, levelers, puddler, and cage wheel etc.

Fig. 6.5: Rotavator

Fig. 6.6: Land leveller

Notes

Both animal and machine powers are employed to operate secondary tillage implements, however machine power is more commonly used in recent years.

6.5.3 Few crops specific special secondary tillage operations are carried out as briefed hereunder.

Tillage practices carried out in the field after planting of a crop are known as intercultural operations. Hoeing, earthing up and weeding are such operations performed in standing crops. These operations are done purposively for loosening the soil to provide well aerated environment to roots, controlling weeds present in crop and making ridges and furrows to facilitate irrigation. Besides, few more operations such as levelling and puddling are practised as special practices in crop production.

a) **Levelling:** A field must be well levelled before planting a crop which is achieved by using a plank, leveller, ladder, scrapper, or laser land leveller, etc. The benefits of land levelling include, better nutrient use efficiency, better control of weeds, uniform distribution of water, uniform crop growth and higher yield.

   Accuracy of levelling can be improved with use of laser land leveller. In India, this laser guided systems are being adopted by farmers in sizable area with 50% more levelling accuracy as compared to other methods.

b) **Hoeing:** It is the practice of breaking the hard soil in standing crop field with the help of tools like hand hoe, wheel hoe, spade, cultivator, trench hoe, and garden rake, etc. Weeds are uprooted during hoeing and are either removed or incorporated there.

Notes

c) **Earthing up**: It is the practice of heaping up soil around the base of crop plants so as to make the plants stable against wind. In this process ridges are formed in crop rows and furrows in inter-row spaces. Earthing-up also facilitates irrigation in furrows and control of weeds.

Fig. 6.7: Earthing up in potato

d) **Weeding**: It is another intercultural operation carried out manually or mechanically to make the crop weed free. In dry soils dryland power weeders can be effectively used for weeding and wetland power weeders used under wet conditions particularly for rice. Manual uprooting of weeds leads to ineffective weed control as aerial parts of weed plants are detached from roots which remain inside soil and regrow after a few days.

e) **Puddling:** Puddling refers to the practice of ploughing of soil in standing water repeatedly till soft and muddy texture is obtained. It is an essential cultural practice in transplanted rice where seedlings are planted in soft puddled soil.

Fig. 6.8: Puddling of soil before rice transplanting in field

Rice is grown with standing water throughout its growth stages for which water needs to remain ponded in the field with little percolation. It is only possible with the creation of a layer that is impermeable to percolation of water to maximum extent. Puddling operation forms that impervious layer below the surface to reduce deep percolation losses of water.

It is a general feeling of farmers that, transplanted rice characterised by puddling operation produces better rice yield than that under unpuddled direct seeded method. Few advantages of puddling are

- creation of impervious soil layer which ensure standing water in rice field
- good control of weeds as incorporated and decomposed in puddling
- facilitates easy transplanting of seedling due to soft mudded condition

However, puddling deteriorates soil structure separating sand, silt and clay from their natural structural orientation. Soil becomes very hard after harvest of rice due to accumulation of clay particles on upper layer of soil upon puddling. It results in poor physical soil condition leading to low soil productivity.

Process of Puddling:

Step -1
- **After primary tillage in dry soil water is allowed to over saturate the soil so as to soften it.**

Step -2
- **Puddling is carried out with tractor drawn tyned cultivator, desi plough, harrow, rotavator or puddler.**

Step -3
- **Soil aggregates get separated and weeds are uprooted and buried with pulverisation of wet soil.**

Step -4
- **Once again 5-10 cm water is allowed in the field and second plough is given 2-3 days after ponding water.**

Step -5
- **Proper puddled condition is judged by taking a handful of mud into the hand and when pressed if flows out freely through fingers, then it is considered perfect.**

Generally depending upon the texture of soil, 2-3 puddling operations are carried out.

Conservation Tillage

It is well accepted that, natural structure of soil is damaged upon conventional tillage which deteriorates soil physical properties. Removal of crop residues and presence of loose soil very often cause losses of productive top soil through erosion. Generally

Notes

minimum of 3-4 tillage operations are carried out in field which cause huge energy consumption and environmental pollution due to burning of fuel. All these reasons led to the development of concept of conservation tillage system comprising of minimum tillage, zero tillage, and stubble mulch tillage, etc. Conservation of soil, water, energy and soil biodiversity are the objectives of this system.

I. Minimum Tillage

Some times the number of tillage operations can be reduced without affecting soil environment for ensuring good germination of crops. Minimum tillage is also called reduced tillage. It comprises soil disturbances but to a lesser extent than that carried out under conventional tillage. Crop residues are allowed in the field for conserving soil and water.

II. Zero Tillage

Tillage operations are reduced extremely and limited only to the spot where the seed to be sown. Without tillage, weeds may become problematic which are controlled using non-selective herbicides prior to seeding. This tillage system conserves soil and water, saves fuel or energy and eventually becomes profitable.

INTEXT QUESTIONS 6.5

1. Mechanical manipulation of soil to provide a medium for crop growth is known as ....
2. Who is considered as Father of Tillage?
3. Which of the following are the primary tillage implements?

   a. Mould Board Plough　　b. Country Plough

   c. Disc Plough　　d. All of these
4. What is the main objective of doing secondary tillage?
5. Puddling is an useful practice in

   a. Wheat　　b. Green gram

   c. Mustard　　d. Rice

6. Which type of tillage is advocated to reduce the harmful effects of conventional tillage?

6.6 SEEDS AND VARIETIES

6.6.1 Seed

Seed is the primary or basic input in crop production. Use of good quality seed leads to higher production. Quality seeds should be clean (free from stones, soil particles, weed seed), pure (true to the type seeds, without presence of seeds of other distinguishable varieties), healthy (free from pest and disease), dry (moisture content, 10-12%) with good germination percentage.

6.6.2 Type of Seeds

Based on sources of seed production and producer, the seeds are classified into five groups. All good quality seeds meeting the minimum seed standards are labeled with proper information tags.

1. **Nucleus seed** is the original seed produced by the developer.
2. **Breeder seeds** are produced under the supervision of the breeder.
3. **Foundation seeds** are the progeny of breeder seeds that maintains highest standard of genetic identity and purity and produced under direct supervision of technical persons. It has white colour tag.
4. **Certified seeds** are the progeny of foundation or breeder seeds that produced by research institutes, departments or farmers following specific standards in large quantities for distribution to the farmers. The certified seed has a blue color tag. The genetic purity decreases gradually from nucleus seed to certified seeds. The certified seed must be obtained from certified growers, sellers, states departments, state agricultural universities and research institutes.

6.6.3 Variety

A variety is a uniform population of a particular plant species with some special characteristics. Cultivated varieties in short are called as cultivars. Different varieties of a same crop differ in production potentials and in other characteristics too. Selection of suitable variety of the chosen crop is the most important factor deciding crop productivity and profitability.

6.7 SOWING AND TRANSPLANTING

Crops are established in field through sowing or transplanting. Most of the field crops are directly sown in fields where as in few crops like rice, tomato, brinjal, transplanting is a common method of establishment. However, for raising a healthy seedling, the seeds need to be treated properly before sowing.

6.7.1 Sowing

Sowing is the practice of placing seeds in soil for germination and establishment of a good crop stand. Crop stand in field depends upon a number of planting variables such as seed rate, time of sowing, depth of sowing and method of sowing.

- **Seed rate:** Seed rate is defined as the quantity of seed required per unit land area for optimal crop stand and economically optimal yield. Seed rate for a particular crop determines the final plant population in the field. Higher seed rate increases the competition between crop plants while low seed rate reduces the plant population and hence the crop yield. An optimal seed rate should be used for higher crop production. It changes with test weight, plant spacing, purity and germination percentage of the seed. It is expressed in kg/ha or g/ha depending upon the quantity of seeds.

- **Time of sowing:** Time of sowing influences the productivity of crop to a great extent. Prevalence of suitable temperature and soil condition favourable for seed germination and subsequent crop growth decide the optimum time of sowing. Therefore, season wise optimal time of sowing for different regions of the country has been identified. Timely sowing enhances crop productivity, whereas delayed sowing normally reduces it. Under rainfed conditions, availability of soil moisture is an important consideration. The optimal time of sowing for most of the *kharif* crops is June and July while for *rabi* or winter crops October and November and for summer crops it is March- April.

- **Depth of sowing:** The optimal depth of sowing depends upon seed size, reserve food material in seed, coleoptile length and moisture availability. Generally optimal depth of sowing for most of the field crops is 3 - 4 cm. The crops with larger seed sizes and reserves like maize, groundnut and castor can be sown at a greater depth of 6 cm. However, smaller sized seeds of pearl millet, sesame and mustard can be sown at 2-3 cm and for even very small seeds like tobacco the optimal depth of sowing is 1 cm.

- **Method of sowing:** Seeds are sown directly in main field or in nursery bed for raising seedlings. Direct seeding in main field can be done in three methods i.e. broadcasting, dibbling and drilling. Direct seeding can be practiced both in dry and wet conditions but dry seeding is sometime more acceptable in mechanized seeding.

  - **Broadcasting**: In this method seeds are spread over the soil by hand or mechanically by using seed broadcasters. Seeds are then covered with soil by a light plough or planking. It is the cheapest method of sowing. However, spacing and uniformity maintenance is difficult leading to poor plant population and limited scope for mechanical intercultural operation.

  - **Dibbling**: In this method, a seed or few seeds are placed in each holes by a dibble or hand at a particular spacing and thereafter covered with soil. It is more time consuming and laborious but provides uniform germination with lower seed rate compared to broadcasting.

  - **Drilling**: In this method crops are sown in lines using seed drills at a requisite spacing. It helps in sowing at uniform depth leading to even crop stand. It also reduces seed rate and provides scope for fertilizer placement along with sowing and intercultural operation.

6.7.2 Transplanting

Transplanting is the removal of an actively growing seedling from one place and planting again in main field for further growth and crop production. In this method the young seedlings are raised with proper care by sowing seeds in a small area called **nursery**. Transplanting is a common practice in rice, tobacco and some vegetable crops. It is also recommended for other crops like finger millet, pearl millet, mustard etc. which are conventionally grown by direct seeding.

Majority of rice fields in India are transplanted and that too manually. Alternative to manual transplanting, mechanized transplanting using a paddy transplanter is recommended because of higher efficiency and labor-saving compared to manual transplanting. It requires only 1 person day to transplant 1 ha of land as compared to manual method that utilizes 20-25 person days. Seedling nurseries usually use 5"10% of the total transplanting area. About 40 kg of seeds is sown in nursery to transplant 1 ha of main field for manual transplanting. 20-25 days old seedlings are uprooted and transplanted. In mechanical transplanting a special type nursery called mat nursery is prepared which uses 18-25 kg seeds to transplant 1ha field.

Notes

Fig. 6.9: Transplanting of rice in puddled field

Fig. 6.10: Rice nursery by wet method

Fig. 6.11: Paddy transplanter for mechanical transplanting

INTEXT QUESTIONS 6.6

1. What are the parts of a good viable seed?

2. How many types of seeds are there based on production source?

3. Foundation seed has tag colour of

    a. Blue

    b. Green

    c. White

    d. Orange

4. State whether true or false.

    a. Hybrids yield less than other type of varieties.

    b. Registered seeds are the progeny of the foundation seeds.

    c. Seed is an immature ovule.

5. Method of sowing where seeds are spread over the soil by hand

    a. Broadcasting

    b. Drilling

    c. Transplanting

    d. Dibbling

Notes

ACTIVITY 6.2

Visit a local agriculture shop selling seeds of different crops/Beej Bhandar. Check the packets/bags of seed. Identify the type of seed being sold in the market. Alternatively, you can also interact with the local farmer to know about the nature of seeds used by them.

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ACTIVITY 6.3

Collect some seeds of any crop. Divide them into two parts. Place one part of these seeds in your garden through line sowing method and other part through broadcasting method. Take proper care for their germination and growth. Record your observations regarding plant growth pattern in both the type of sowing.

....

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ACTIVITY 6.4

Visit to your nearby farm and ask the farmers about the crop that they are growing. Group them according to their growing season and usage and prepare a chart. (Consult the section 'Classification of the crops' for this purpose)

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WHAT YOU HAVE LEARNT

- Field crops are classified according to various criteria. On the basis of the growing season, crops are classified in to kharif (monsoon), rabi (winter) and zaid (summer) crops. Further, such crops are classified into grain, pulse, oilseed, forage, fibre, sugar, spices, medicinal and green manure crops based on usage.
- A same piece of land may be occupied by one crop (mono cropping), two crops (double cropping) or more than two crops (multiple cropping) in a year. At a particular time in a year, a land may be occupied by more than one crop following a definite plant geometry that is called intercropping.
- Physical, chemical and biological properties of soil can vary from region to region. One of the main drivers for this variation is local climate. Such a unique combination of climate and soil are specific to the crops. Therefore, it is not advisable to cultivate any crop without considering their specific soil and climatic requirements.
- Mechanical manipulation of soil to provide an ideal medium for crop establishment and growth is called tillage. It improves physical condition of soil, controls weeds, and provides good contact between seed and soil.

TERMINAL QUESTIONS

1. Enlist and briefly describe about various types of agronomic crops along with suitable examples.
2. What are the criteria to be followed during selection of suitable intercrops?
3. Discuss the benefits of Integrated Farming System (IFS) model in improving farmers income.
4. Describe soil and climatic requirement of rice, wheat, chick pea and sugarcane.
5. Why tillage is carried out before raising any crop?
6. Differentiate between conventional and conservation tillage.
7. What do you mean by intercultural operations?

Notes

ANSWERS TO INTEXT QUESTIONS

6.1

1. 3 types (Kharif, rabi and zaid crops)
2. Kharif season
3. Green gram/ black gram/ pigeon pea/ chickpea/ cowpea
4. Dhaincha (Option c)
5. Nutria cereals

6.2

1. Multiple cropping (Option b)
2. It is a system of cropping where two or more crops are grown together on same area following definite planting geometry.
3. Wheat based/ chick pea-based/ rabi sorghum-based cropping systems
4. True

6.3

1. Integrated Farming system
2. Farming system approach
3. Agriculture, horticulture, fishery, livestocks and allied sectors

6.4

1. Rice/sugarcane
2. Cool-moist and warm-dry weather
3. 21°C
4. Light textured soil
5. Waterlogging

6.5

1. Tillage
2. Jethro Tull
3. All of these (Option d)
4. To provide fine tilth for seeding
5. Rice (Option d)
6. Conservational tillage

GLOSSARY

Hoeing: Hoeing is the practice of breaking the hard soil in standing crop field with the help of tools like hand hoe, wheel hoe, spade, cultivator, trench hoe, and garden rake, etc.

Integrated farming system (IFS): It is a sustainable agricultural system that integrates livestock, crop production, fish, poultry, tree crops, plantation crops and other systems that benefit each other.

Intercultural operations: Practices carried which are out in the field after planting of a crop are known as intercultural operations.

Puddling: It refers to the practice of ploughing the soil in standing water repeatedly till soft and muddy texture is obtained.

Tillage: Tillage refers to manual or mechanical manipulation of soil to provide an ideal medium for crop establishment and growth.

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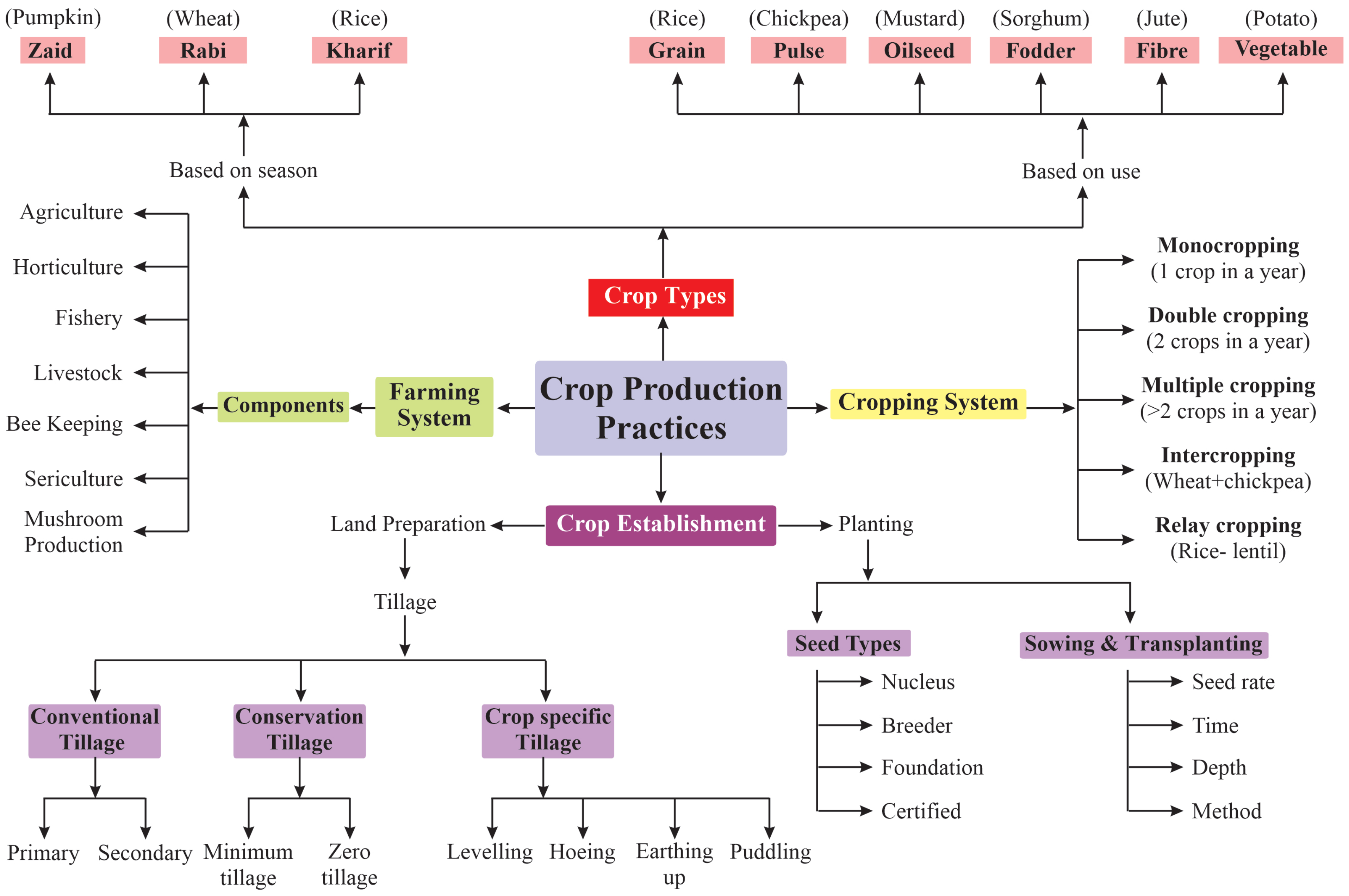
3. Principles of Agronomy & Agricultural Meteorology, B.Sc. (Agriculture), e-KrishiShiksha, Agricultural Education Division, Indian Council of Agricultural Research, New Delhi (https://ecourses.icar.gov.in/).

WHAT YOU HAVE LEARNT



Notes

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NUTRIENT, WATER AND WEED MANAGEMENT

Plants are like human beings. They need adequate food at right time for optimum growth and development. In absence of proper nutrition, they show characteristics symptoms. Similar to human body, plants are also infected by bacteria, fungusand other organisms. A successful harvest of agricultural produce depends heavily on the accurate detection of these plant abnormalities. In this lesson, we are going to learn to about scientific way of managing nutrients, water and weeds for growing a healthy crop.

LEARNING OUTCOMES

After studying this lesson, the learner:

- definesthe essential and beneficial plant nutrients;
- explains the role of proper nutrition in the plant's growth and development;
- identifies water requirement of various crops and the significance of supplying irrigation;
- discusses the different irrigation techniques; and
- describes thepreventive and curative strategies of weed control.

7.1 TYPE OF PLANT NUTRIENTS

Plants absorb a large number of elements from soil but all are not essential for them. Crop plants need certain essential elements or nutrients for their optimal growth and development. These nutrients are taken up from soil, air and water in the form of ions, atoms or their simple molecules or compounds. To be considered as essential,Arnon and Stout (1939) proposed the criteria for nutrients, according to which.

Notes

I. An essential element is one ifplants cannot complete their life cycle due to its deficiency,

II. The deficiency can be corrected by supplying that element only.

III. The element is directly involved in the metabolism of the plant.

There are 17 mineral elements essential for plant growth which is classified on the basis of amount taken up by the plants. Carbon (C), hydrogen (H), and oxygen (O) are obtained from air and water, called as **basic or framework elements**. The six **macronutrients**, nitrogen (N), phosphorus (P), potassium (K), Calcium (Ca), Magnesium (Mg) and Sulfur (S), are required by plants in large amounts. Out of these, N, P and K are considered as primary or major nutrients because of their requirement in larger quantities. Ca, Mg and S are called as secondary nutrients as they are required in relatively lesser amount. The rest of the nutrients (8) are required in trace amounts (**micronutrients**). Essential micronutrient elements include Boron (B), Chlorine (Cl), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn), Molybdenum (Mo) and Nickel (Ni). Few elements are not considered essential (as per the Arnon & Stout definition) to all plants but are beneficial to growth of some, are called as **beneficial** nutrients e.g., Sodium (Na), Silicon (Si) and Cobalt (Co), etc. The classification of essential plant nutrients is summarized as:

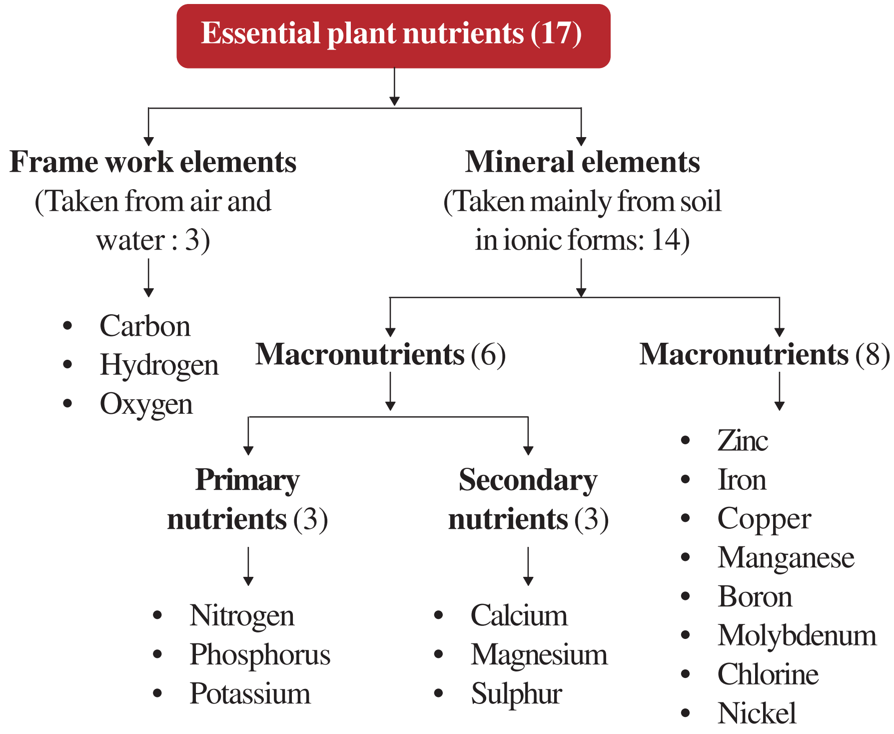

Fig. 7.1: Classification of essential plant nutrients

Notes

Table 7.1:The different chemical forms of nutrients taken up by plants

Essential nutrient	Forms absorbed by plants	Average concentration in plant tissue
Nitrogen	NH_4^+, NO_3^-	1.5%
Phosphorus	$H_2PO_4^-$, HPO_4^{2-}	0.2%
Potassium	K^+	1.0%
Calcium	Ca^{2+}	0.5%
Magnesium	Mg^{2+}	0.2%
Sulphur	SO_4^{2-}	0.1%
Iron	Fe^{2+}	100 mg/kg
Manganese	Mn^{2+}	20 mg/kg
Zinc	Zn^{2+}	20 mg/kg
Copper	Cu^{2+}	6 mg/kg
Nickel	Ni^{2+}	0.1 mg/kg
Boron	H_3BO_3	20 mg/kg
Molybdenum	MoO_4^{2-}	0.1 mg/kg
Chlorine	Cl^-	100 mg/kg

7.2 ROLE OF NUTRIENTS

Each essential nutrient has specific roles in plant as abstracted in Table 7.2

Table 7.2: Functions and deficiency symptoms of essential nutrients in plants

Nutrient	Functions or roles in plants	Deficiency symptom
Nitrogen	A major component of proteins, hormones, chlorophyll, vitamins, and nucleic acids	Yellowing of the older leaves and stunted growth

Notes

Phosphorus	Part of nucleoproteins, stimulates root growth, energy storage and transfer function	Purpling of plant parts
Potassium	Activator of many enzymes, regulates osmotic potential in cells, helps in translocation of sugars and carbohydrates, imparts resistance against pests	Marginal leaf burn and tip burn, speckled and mottled leaf
Calcium	Important for cell division, cell wall formation, nitrogen accumulation	Stunting of new growth in stems, flowers and roots
Sulfur	Constituent of many amino acids and vitamins, important nutrient for oilseed and cruciferous crops.	Yellowing of younger leaves
Magnesium	Component of chlorophyll	Interveinal chlorosis in older leaves
Iron	Component of enzymes, essential for chlorophyll synthesis	Interveinal chlorosis in new leaves
Manganese	Activates enzymes, involved in chlorophyll synthesis and carbohydrate metabolism	Interveinal chlorosis in younger leaves
Zinc	Components of many enzymes, essential for plant hormone auxin synthesis	Stunted growth, reduction in internodes, mottled leaf
Copper	Component of enzymes, involved in photosynthesis	Terminal bud die, interveinal chlorosis
Boron	Plays role in sugar transport, pollination, fruiting	Terminal buds appears as witches broom, dying of growing points
Chlorine	Turgor regulation, disease resistance, fruit quality	Deficiency rarely seen. When deficient, appear chlorotic

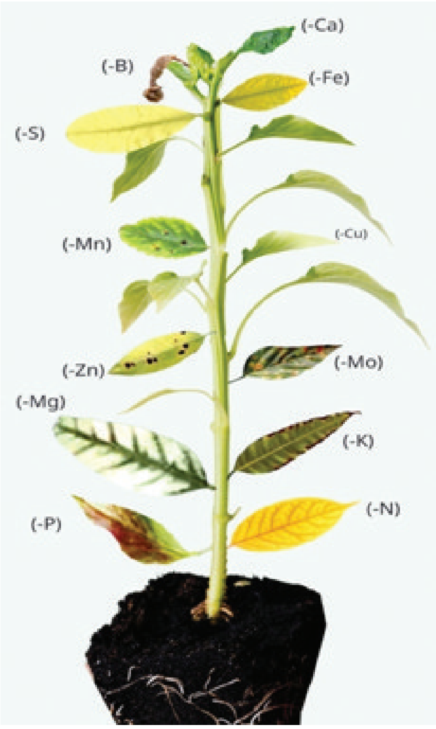

Fig. 7.2: Deficiency symptoms of essential nutrients in plants

7.3 SOURCES OF NUTRIENTS

Nutrients taken up by plants are supplied from soil, crop residues, fertilizers and manures. **Fertilizers** are chemicals produced industrially which are rich in specific nutrients. **Manures** are organic in nature prepared from plant and animal residues. Soil health is decided by its physical, chemical and biological characteristics. Soil is a reservoir of all nutrients as required by crop plants. However, removal of those nutrients by raising crops without replenishment strategy results in depletion of soil fertility. Under this circumstances, nutrient demand of crops need to be met from external sources as organic manures, chemical fertilizers, biofertilizers, and crop residues, etc.

A. Organic Manures: These are of two types

a. **Bulky Organic Manure:**Farm yard manure (FYM), compost, vermicompost and green manures are called bulky organic manures as they are applied in large quantities. These manures contain less amount of plant nutrients. These improve soil physical condition, increase activities of microorganisms and supply all the plant nutrients, though in small quantities. FYM is prepared from cattle dung, animal bedding material and plant residues. Compost is produced from crop residues, grasses, leaves and

Notes

cattle shed bedding materials. Green manure crops are generally legumes which have ability to fix atmospheric N in root nodules in symbiotic association with bacteria. Besides enriching soil nitrogen status, they supply other nutrients when incorporated in soil. Most common green manure crops are dhaincha *(Sesbaniaaculeata)* and sunnhemp (*Crotalaria juncea*).

b. **Concentrated manure** contain higher amount of plant nutrients than bulky organic manure. They are oilcakes, blood meal, meat meal, bone meal and fish manure. Oilcakes of neem, karanj, groundnut, sunflower, safflower, castor, soybean, linseed, and mustard, etc. are used as source of nutrients.

B. Bio-fertilizers

Soil is home to a large number of microorganisms out of which many are beneficial to soil and crop. They supply or make the nutrients available to plants, especially nitrogen (N) and phosphorus (P). However, due to their declining population and activities, they are added externally as bio-fertilizers. These are bio-inoculants or products containing live and latent cells of such microorganisms. Bio-fertilizers are either inoculated with seeds before sowing or applied to soil.*Rhizobium*, blue green algae, azolla, *Azotobacter*, *Azospirillum*and *Acetobacter*are nitrogenous bio-fertilizers, whereas, phosphate solubilising microorganisms (PSM), vesicular arbuscular mycorrhiza (VAM) solubilize insoluble soil P and make it available to plants. Similarly, potassium mobilizing bio-fertilizers contain bacteria that are capable of solubilizing inorganic potassium from insoluble compounds and providing it for plant uptake.

C. Fertilizers

Chemical fertilizers are inorganic or synthetic organic materials with concentrated nutrients which are applied to soil or plants to supply plant nutrients. Plants get nutrients quickly after application of fertilizers unlike that from organic manures. Fertilizers usually supply major nutrients like N, P and K which are applied in higher amounts, e.g. urea, di-ammonium phosphate (DAP), muriate of potash (MOP) etc. Micro-nutrients based fertilizers are also available in marketas these nutrients are also deficient in soil. Important micro-nutrients for which fertilizers are available are boron, zinc, iron and molybdenum.

The nutrient content of a fertilizer is labeled on the bag or container, and called fertilizer grade.It is the minimum guaranteed concentration of nutrients expressed in percentage of N, P and K in order. The fertilizer grade information depicts the percent of total elemental nitrogen (N), percent available phosphorus (P_2O_5)

and percent water soluble potassium (K_2O). Thus, a fertilizer grade is presented as N-P_2O_5-K_2O. A complex fertilizer with grade 10-26-26 means, the material contains 10% N, 26% P_2O_5 and 26% K_2O.

Notes

INTEXT QUESTIONS 7.1

1. How many mineral elements are essential for plant growth?

2. Which of the following is a micronutrient?

   a. Calcium   b. Magnesium

   c. Potassium   d. Iron

3. Element that is responsible for disease and pest resistance in plants

   a. Potassium   b. Chlorine

   c. Nitrogen   d. All of these

4. Bulky organic manure contains higher amount of plant nutrients than concentrated manures. (True/False)

5. Which essential nutrient for plant is supplied by urea fertilizer?

7.4 CLASSIFICATION OF FERTILIZERS

Fertilizers are classified as straight or complex fertilizers based on the number of primary nutrients contained in them. **Straight fertilizers** supply only one primary nutrient, N or P or K. Urea, single super phosphate, potassium sulphate, etc. are examples of such fertilizers. These are again grouped into nitrogenous, phosphatic and potassic fertilizers. Fertilizers which contain two or three primary nutrients are called **complex fertilizers**. Di-ammonium phosphate (DAP), urea phosphate, NPK 19-19-19 etc. are such fertilizers. When it contains two of the primary nutrients, it is designated as **incomplete complex** fertilizer, while those contain all three primary nutrients are called **complete complex** fertilizers. They are available in granular formulation with good physical condition and are cheaper compared to individual fertilizers.

Fertilizers are classified as **high and low analysis fertilizers** based on the content of nutrients present in them. High analysis fertilizers have a concentration of more than 25% total primary nutrients, e.g. di-ammonium phosphate has 18% N + 46% P_2O_5, urea (46% N), and urea phosphate (17% N + 44% P_2O_5). Some fertilizers have total

primary nutrient content of less than 25%, are called low analysis fertilizers, such as single super phosphate (16% P_2O_5), ammonium sulphate (20% N) etc.

7.4.1 Selection of Fertilizers

Right choice of fertilizers for crop production is crucial for ensuring good crop growth, higher profitability and soil health. There are number of options before farmers while selecting which fertilizer to apply for their crop. It is not decided by a single factor rather several factors influence their decision, important among those are,

- Type of crops (cereals/pulses/oilseeds/vegetable crops)
- Time of application with respect to crop growth stages
- Routine application or application to rectify deficiency
- Price of kg nutrient in the fertilizer
- Number of nutrients contained in fertilizer
- Efficacy of fertilizer on plant growth
- Storability and ease of transportation
- Peerfarmers' feedback on the fertilizers
- Recommendations by extension system

7.4.2 Fertilizer Management in Crops

Three important aspects of fertilizer management required to be considered are

I. **Type of Fertilizers:** Factors influencing the type of fertilizers to be used are explained earlier.

II. **Time and Dose:** The entire dose of nitrogenous fertilizer is not given to crop at once, rather applied to crops in different splits following the schedule. The first application happens before or during sowing/planting is called as the basal application. Subsequent application during growth stages of crop is called as top dressing. Generally, 50% of total N, and full dose of P and K fertilizers are applied as basal and the rest N amount is given in 1-2 splits depending upon the crop and soil types. N is highly mobile in soil unlike P and lost from rhizosphere zone by various processes for which nitrogenous fertilizers are applied in split doses. Full dose of soil applied phosphorous and micro-nutrients are given as basal.

Optimum dose of fertilizers of a crop depends upon the fertilizer need of the crop and nutrient supplying capacity of soil. Climate and crop management practices also influence it. Therefore, the dose of fertilizer for different crops varies across the locations. Accordingly, states of India have different fertilizer recommendations.

N is applied at a relatively higher rates compared to other nutrient due to its low use efficiency. Rice consumes about 40% of total fertilizer N consumption in India. Usually, rice responds up to 120 kg N/ha and some places even up to 150-180 kg/ha has also been observed. Leguminous crops generally require a basal dose of 15-20 kg N/ha as they meet most of their N demand from atmospheric N fixation.

III. **Methods of Application**: Further, fertilizers are applied through different **methods**, such as broadcast, placement, foliar application and fertigation. **Broadcast** is the most preferred method adopted by farmers because of ease of application and cost effectiveness. However, nutrient use efficiency is very low if adequate soil moisture is not available. In contrast to this method, fertilizers can be put near the root zone as **placement** either manually or using seed-cum-fertilizer drills. Due to low mobility and fixation of P in soil, placement method is the most appropriate for phosphatic fertilizers. Pellet application of urea fertilizer improves its efficiency under deep water rice ecology.

Fertilizers which are available in liquid formulations are given to crops as **foliar application**. Besides, few solid form fertilizers like urea, DAP, borax, zinc sulphate etc. are also recommended for foliar application. Requirement of lower dose, high use efficiency and quick absorption of fertilizers by leaves are major advantages of foliar application. Above discussed methods are followed for field and horticultural crops under open cultivation condition. In protected cultivation or when drip irrigation is installed, fertilizer is precisely applied through irrigation water called as fertigation. Water soluble fertilizers with high water solubility are used here.

INTEXT QUESTIONS 7.2

1. Nitrogen content in DAP is

   a. 18% b. 30%

   c. 25% d. 46%

Notes

2. State whether true (T) or false (F).

   a. Straight fertilizers supply only one primary nutrient.

   b. Generally nitrogen is applied at lower rate due to its high application efficiency.

   c. Fertigation is the most preferred method of fertilizer application by farmers.

7.5 WATER MANAGEMENT

Water is all around us. It is the lifeline of every living being on earth. Just imagine if water would not be there also how life would be? Like animals or other organisms, water is absolutely necessary for crop plants too. But how to manage the water in best way for the crops is essential to make the system sustainable. In this section let's study the different principles and practices involved in water management for raising a crop successfully.

7.5.1 Irrigation

Water is one of the key ingredients of life, may it be human, plant, or animal. It is required for photosynthesis, translocation of nutrients, and maintaining heat balance in the plant body. Soil water is the major source of water for plant uptake which is depleted due to evaporation from the soil surface, transpiration through the plant, and deep percolation into the soil beyond the root zone. Roots cannot grow if the soil is dry. Rainfall and other forms of precipitation are the natural sources from which the depleted soil water is replenished into the soil. When natural rainfall is not sufficient to supply the water required for plant growth, there is a need for the artificial application of water to the crops. Irrigation can be defined as the artificial application of water to soil to supplement rainfall for crop production. It provides a favorable environment for better crop growth and yield.

7.5.2 Soil Water

Soil water relations deal with those physical properties of soil and water that affect the movement, retention, and absorption of water by plants. These must be understood in order to plan or improve an irrigation system. The soil is a poly-phasic system viz., solid, liquid and gaseous phases. The solid phase constitutes the soil matrix, the liquid phase consists of soil water (which always contains dissolved substances so that it should properly be called the soil solution) and the gaseous phase is the soil atmosphere. The liquid portion of the soil which consists of water, dissolved minerals, and soluble organic matter fills part or most of the spaces between the solid particles. This water is

absorbed by the plant roots and must be periodically replenished by rain or irrigation for the successful production of crops.

7.5.3 Water Movement in Soil

Immediately after the application of irrigation or receipt of rain, water enters the soil. It moves laterally, upwardly, and/or downwardly from higher water potential to lower potential sites.**Infiltration** is the process of entry of water into the soil, generally by downward flow through all or part of the soil surface. The movement of water within the soil influences the water supply to roots and also contributes to the underground water table. It occurs in three different ways:

a) **Saturated Flow:** Saturated flow occurs when all pores are filled with water either due to rain or irrigation or under a waterlogged situation. The major driving force in such flow is gravity.

b) **Unsaturated Flow:** The unsaturated flow occurs in soil micropores due to differences in soil water potential.

c) **Vapor Movement:** When soil becomes dry, water from micro pores is also emptied and mainly present in the form of vapour. The movement occurs due to a difference in vapour pressure called vapour movement.

7.5.4 Retention and Uptake of Water

Water in the soil does not exist individually. A water molecule sticks to another water molecule with great energy and this property is called **cohesion**. Water attaches itself to surfaces of many substances through the property of **adhesion**. Because of these forces water in the soil exists as a thin film in the pore spaces. When water enters the soil it first fills the micropores and then macropores are filled whereas when the water leaves out of the soil it empties the macropores first and then the micropores are drained up.

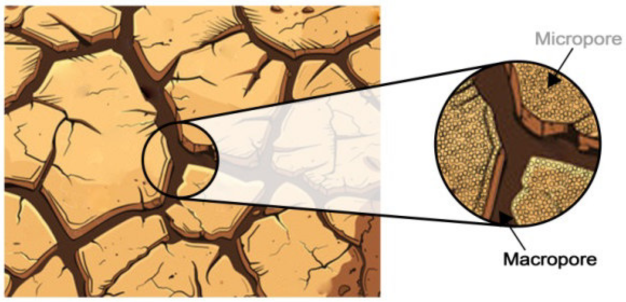

Fig. 7.3: Macro and micro pores in soil

7.5.5 Water Requirement

Water requirement is defined as the quantity of water required by a crop for its normal growth and development under a given field conditions. Water requirement (WR), if considered as a demand, it includes the quantity of water required for evapotranspiration (ET), plus the losses during the application of irrigation water and the quantity of water required for special operations such as land preparation, transplanting, leaching of salts below the crop root zone, and frost control, etc.Considering the supply sources, water requirement is the sum total of quantity of water supplied through irrigation (IR), effective rainfall (ER), from soil moisture in crop root zone (“S) and ground water (GW). Water requirement is expressed in depth per unit of time. **Irrigation requirement**(IR) is the total amount of water applied to a cropped field for supplementing effective rainfall, soil moisture, and groundwater contribution to meet the crop water requirements for optimum growth. It is a part of the total water requirement of the plant.

WR = ET loss + losses during irrigation + water required for special operations

= IR+ER+S+GW

(WR: Water requirement, ET: Evapotranspiration, IR: Irrigation requirement, ER: Effective rainfall, **S:** soil moisture contribution, GW: ground water contribution)

Water requirement along with number of irrigations required by major field crops are given in table 7.3.

Table 7.3: Water requirement of major field crops

Crop	Water requirement in mm	Number of irrigation
Rice	1100-1250	18
Maize	500-600	8
Pulses	200-450	4
Groundnut	500-550	10
Sugarcane	1800-2200	24
Cotton	550-600	11

The above data on water requirement and number of irrigation of crops are average figures only, which vary according to the duration of crop, soil types, climatic conditions and crop management practices.

7.5.6 Scheduling of Irrigation

Irrigation scheduling is a technique of deciding the time of irrigation and the quantity of water to irrigate for obtaining optimal production. The main purposes for scheduling irrigation are to optimize the water use in irrigation, decrease the cost, improve soil hydrological condition and obtain higher yield. Irrigation scheduling depends upon the depletion of available soil moisture in the root zone, evaporative demand of atmosphere and growth stage of crop when water is essential called as critical crop growth stage. These stages of irrigation have been identified in different crops at which occurrence of moisture stress leads to decrease in crop yield.

INTEXT QUESTIONS 7.3

1. What is irrigation?

2. Which of the following is not a natural source of water in soil?

   a. Rainfall b. Snow

   c. Hail d. Irrigation

3. State whether true or false.

   a. Unsaturated flow occurs when all pore spaces in soil are filled with water.

   b. Water in soil moves from higher potential to lower potential.

4. Which of the following crop has maximum water requirement?

   a. Rice b. Maize

   c. Sugarcane d. Cotton

7.6 METHODS OF IRRIGATION

Every crop is not irrigated same way. Different irrigation methods are followed to supply needed quantity of water to the crop, minimizing the field losses and improving application efficiency. Each method has specific advantages that make it suitable for

Notes

certain farming conditions, crop types, climate and geographical settings. These are classified as surface methods and micro-irrigation methods (sprinkler and drip irrigation).

7.6.1 Surface Irrigation

These methods are widely used in many crops in India. Flooding, check basin irrigation, basin method, border strip and furrow irrigation are different types of surface irrigation methods followed in different crops.

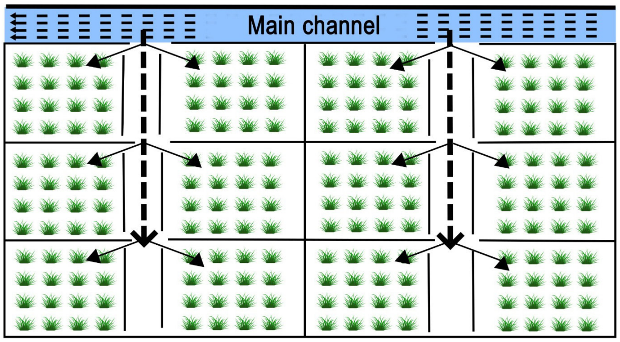

Fig. 7.4: Check basin irrigation

In the **flooding method**, water is allowed from the channel into the entire field. This method is usually practiced in low-land rice cultivation. The **check basin method** is suitable for closely spaced crops, like groundnut, wheat and finger millet, etc. The field is divided into smaller unit areas with bunds around it forming basins, within which the irrigation water is applied.

In **furrow method** of irrigation, ridges and furrows are made to grow the crop on ridges and apply irrigation through furrows.

Fig. 7.5: Furrow irrigation

7.6.2 Micro-Irrigation Methods

Water use efficiency in surface irrigation methods is very low due to loss of large amount of water during application through percolation, seepage and overflow. In contrast, micro-irrigation is the slow application of water as continuous drips, tiny streams or miniature sprays above or below the soil surface. Micro-irrigation system broadly of two types, sprinkler irrigation and drip irrigation system. Water is applied via pressurized piping system which requires pumps for developing the required pressure for delivering water through pipelines. Micro-irrigation system is effective in saving waterand increasing water use efficiency as compared to the conventional surface irrigation method.

Sprinkler Irrigation

Sprinkler irrigation is a method in which water is sprayed/sprinkled with pressure over the crop canopy. It is suited for most row, field and tree crops. Sprinkler systems are also used for irrigating lawns and gardens. The sprinkler breaks up the water into droplets sized 0.5–4 mm and spray released through nozzles. The drop size is controlled by pressure and nozzle size of the sprinklers. Sprinklers are operated at recommended pressure levels so as to ensure proper distribution of water. This method is not suitable for areas with hot dry winds as a considerable amount of water is lost as evaporation.

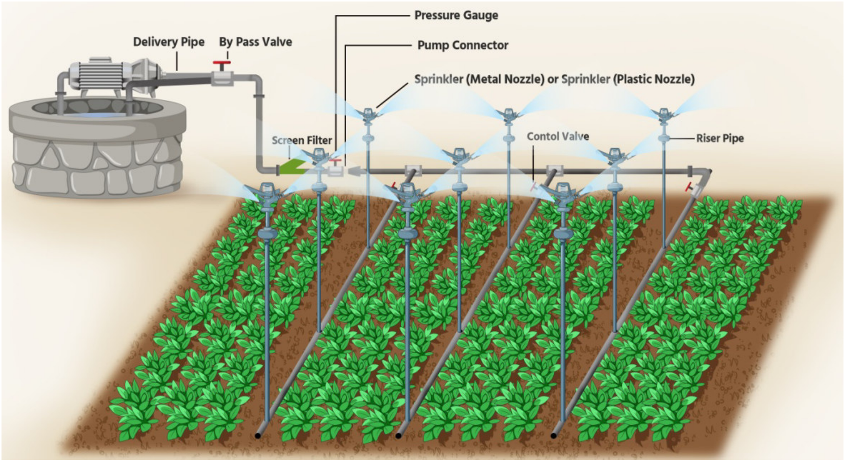

Fig. 7.6: Layout of a sprinkler irrigation system

Drip Irrigation

Drip is yet another micro irrigation method wherein the precise and slow application of water in the form of discrete or continuous drops. Water is delivered through mechanical devices called **emitters** installed along water delivery lines. This method has the highest

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irrigation efficiency and is useful for crops grown in water-scarce areas, saline areas and widely spaced crops. **Fertigation** is a method of application of fertilizers through irrigation. Fertigation has the potential to apply the precise quantity of water and nutrients both in amount and location as per the plant requirement.

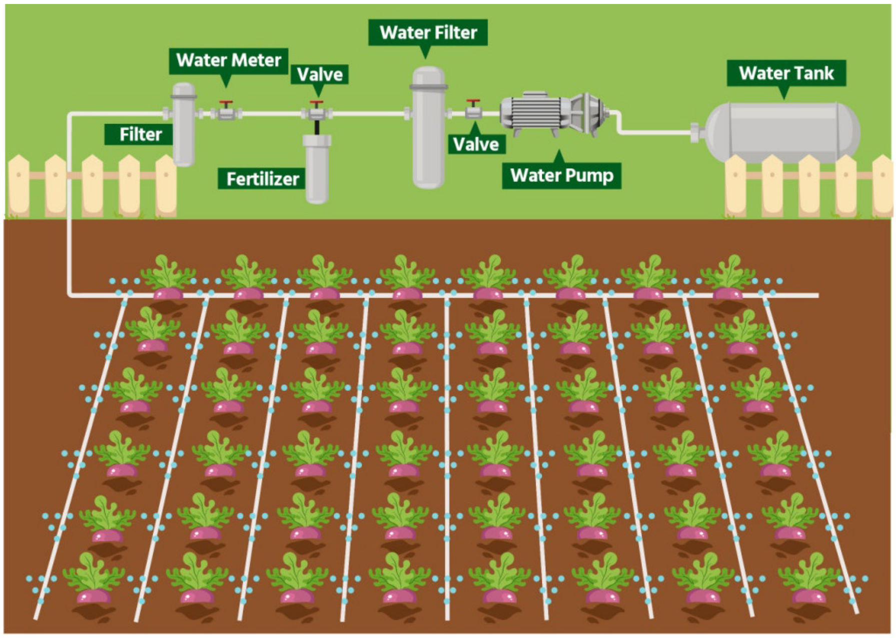

Fig. 7.7: Layout of a drip irrigation system

INTEXT QUESTIONS 7.4

1. Name any two surface irrigation methods.
2. Irrigation type where water is applied in precise and slow way through emitter is ....
3. Irrigation method which is suitable to saline areas

   a. Drip   b. Sprinkler

   c. Furrow   d. Check basin

ACTIVITY 7.1

Visit a nearby agricultural field. Observe how irrigation is being practised by the farmer. Check the type of irrigation whether it surface/sub-surface/sprinkler/drip. Recognize the source of irrigation water (ground water/ canal/well/other). Prepare a layout/sketch of irrigation systems installed in agricultural field.

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7.7 WEEDS: CLASSIFICATION AND CHARACTERSTICS

When you are travelling through a bus or a train you must have seen some plants on the road sides and railway tracks. What are these plants? Whether these are of any use or not? Such question might be there in your mind. When you visit farmer field, along with the crop plants you may also see some other plants growing there. Whether these are planted there or have grown at their own? Really it may be quite interesting for you to understand their biology and characteristics which make them stand in the adverse type of climate. Let us discuss about these weed plants in this section.

7.7.1 Weeds

Among all the plants around us, some plants are of economic value either as a source of food, fiber, fuel, or timber, which we call crop plants. Along with the crop plants, some plants grow voluntarily which are not of any use. These are known as weeds. Weeds can be defined as unwanted or undesirable plants that compete with crops for water, soil nutrients, light, and space and thus reduce crop yields. Weeds are more competitive and adaptable to all adverse environments. Fig. 7.7 shows how weeds are more competitive than crop and growing prolifically utilising nutrients in fertile soil patches. They cause a reduction in yield and quality of the economic product. The extent of losses depends on the intensity of infestation, time of occurrence, and type of weeds.

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Fig. 7.8:Prolific weed infestation in fertile soil patches in a rice crop field

Weeds also interfere with agricultural operations, their presence contaminates the food grains and they harbor organisms like mosquitoes that cause or transmit diseases. Some weeds are poisonous and others produce pollen which causes allergies to humans. Some weeds are useful to us too as they have various cultural and religious importance like *Bermuda* grass used in puja, and some weeds like *Typha* grass used as thatching material. *Cyprus* is used for the preparation of agarbatti. Some weeds are used as vegetable (*Chenopodium album*) for human beings and fodder (*Melilotus alba*) for animals. Weeds have certain medicinal properties and they also act as genetic material for plant breeding.

7.7.2 Classification of Weeds

There are over 30,000 species of weeds all around the world amongst which about 18,000 cause serious losses to crops. Weeds are classified into several categories based on different characteristics. Among these classifications, the important and commonly used are based on morphology, duration, and the number of cotyledons.

Fig. 7.9: Mixed weed flora in rice crop

Depending on the duration of the life cycle, weeds are classified into **annuals**, **biennials**, and **perennials**. Most of the weeds present in crops are annual in nature, their life cycle is short and they compete with the crop plants e.g., *Echinochloa, Chenopodium, Phylanthus*, etc. They usually propagate through seeds. Biennial weeds complete their life cycle in two years or in two seasons e.g., carrot grass, etc. Perennials grow for more than two years e.g., *Bermuda* grass, *Cyprus* sp, star grass, and field bindweed, etc.

Based on the number of cotyledons, weeds are classified as **monocots** and **dicots**. Monocots have narrow and upright leaves whereas dicots have broad and horizontal leaves.

Weeds are also classified as **grasses**, **sedges**, and **broad-leavedweeds** based on their morphological characteristics like leaves, branches, and underground plant parts.

Sedge (Cyperus sp.) Grass (Echinochloa sp.) Broad leaved weed (Ludwigia sp.)

Fig. 7.10: Morphological classification of weeds

7.7.3 Managing Crop Field Weeds

Before managing weeds infesting crop field, it is quite essential to understand how and from where weeds enter crop field. Annual weeds are prolific seed producers which are small in size compared to crop seeds. Whereas, most perennial weeds propagate vegetatively by rhizomes, stolons, bulbs, etc. which remain below the soil and thus making them difficult to eradicate. The vast reservoir of dormant and viable weed seeds in the top layer of soil act as a weed seed bank. Weeds germinate in different flushes at periodical intervals. Most of the weed seeds germinate when proper environmental conditions exist. Often weed seeds from one field enter another through crop seeds as mixture, manures, farm machineries and other dispersal agents like wind and water.

7.7.4 Crop Weed Competition

Till now we understand, weeds compete with crop plants for nutrients, water, light, and carbon dioxide. This relationship between weeds and crop is called as crop-weed competition. Increase in weed biomass in a crop field reduces the crop yield with similar intensity. The period at which maximum crop weed competition occurs is called the **critical period of crop weed competition.** It is the period during which weeding of crop field results in the highest economic returns. That means, the crop field should be kept weed free during this period to obtain maximum yield.

INTEXT QUESTIONS 7.5

1. Unwanted and undesirable plant that competes with crop plant for nutrient, water and sunlight is termed as ....

2. Weed species that is used as vegetables by human beings ....

3. Thepropagating materials of perennial weeds are

   a. Bulb b. Rhizome

   c. Stolon d. All of these

7.8 WEED MANAGEMENT METHODS

Weed management is the approach and set of practices aimed at minimizing the weed infestation in crop field. Preventive and curative strategies are two broad ways adopted to manage weeds. Preventive measures restrict the entry and spread of weed propagules in new fields. Curative methods comprised of eradication, physical, cultural, biological and chemical method. The approach is integrated weed management (IWM) wherein many different weed management methods are used in an integrated way, to manage weeds and to reduce dependency on herbicides.

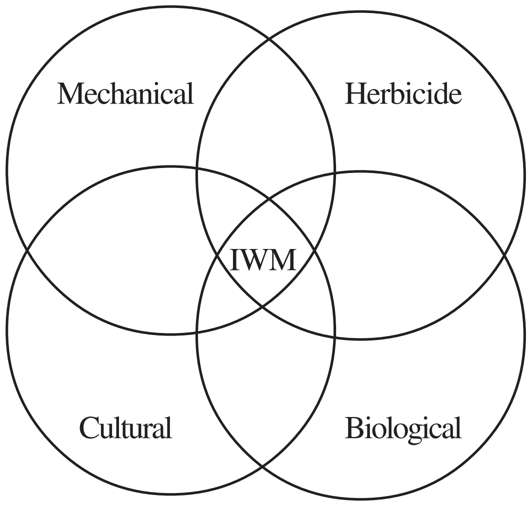

Fig. 7.11: Integration of multiple approaches of weed management

A. Preventive Methods

Important weed prevention practices include

- using clean and weed-free crop seeds,
- using clean implements
- removing weeds before it produces seeds
- use of well decomposed manures

B. Curative Methods

Eradication: Eradication is complete removal of all live plant parts and seeds of the weed from an area. It may be a field/farm/village/geographical region depending upon the need.

Control methods: Control method indicates that weed infestations to be reduced but not necessarily eliminated. Various methods of controlling weeds are physical and mechanical methods,cultural methods, biological control and chemical methods.

(i) Physical and Mechanical Methods

- **Hand weeding:** It involves uprooting weeds from crop field with the help of hoe or khurpi. Besides removal of weeds, soil is loosened which helps in growth of plants. This method is very effective in managing weeds but expensive.

Notes

- **Mulching:** It is the practice of covering the soil in inter-row spaces with straw, crop residues, plastic etc. In absence of light and with the physical barrier weeds find difficult to germinate and emerge.
- **Weeder:** Use of weeding tools such as manual and power operated weeders and tillers etc. for tilling the inter-row soil and uprooting weeds.

(ii) Cultural Methods:

The principle behind this method is to give a competitive advantage to the crop. Different cultural methods which are commonly in use are proper crop stand and early seedling vigor, proper planting method, planting time, crop rotation, stale seedbed technique, smother crops, flooding, soil solarization etc.

Fig. 7.12: Smothering effect of crop on weeds

(iii) Biological Control:

This method refers to utilization of natural living organisms such as insects, herbivorous fish, other animals, disease causing organisms and competitive plants for managing weed population. The herbicide as produced using living organisms, viz. fungi and bacteria are called bio-herbicides, e.g. fungi like *Colletotrichum sp, Bipolaris sp., Phytophthora sp.*

(iv) Chemical Methods:

Herbicides are chemicals capable of killing or inhibiting the growth of plants. Today we have 150 herbicides in common use for selective and nonselective control in different areas. **Selective herbicides** kill only targeted plants or weeds while crops are not affected like 2,4-D, Ethoxysulfuron, Fenoxaprop p ethyl etc. in rice. **Non-selective herbicides**, Glyphosate and Paraquat kill all vegetation that they come in contact with irrespective of whether it is a crop plant or weed. Herbicides are not aimed at substituting the physical, biological, or good crop husbandry methods but to replace the drudgery of manual weeding.

7.8.1 Classification of Herbicides

Based on time of application herbicides are classified as pre-plant, pre-emergence and post emergence herbicides.

1. **Pre-plant Herbicides:** Herbicides which are applied before sowing the crop. However, these are not popular herbicides among farmers. Pre-plant herbicides include Fluchloralin, Trifulralin, Diphenamid etc.

2. **Pre-emergence Herbicides:**These are applied after sowing the seeds but before emergence of weeds i.e. 0-3 days of sowing. These herbicides are of selective in nature and applied on soil. Oxyfluorfen, Pendimethalin, Pretilachlor are pre-emergence herbicides.

3. **Post-emergence Herbicides:**These herbicides are applied after the emergence of weeds and crops. Selective herbicides are used in crops at 2-4 leaf stages of weeds, e.g., 2, 4-D, Bispyribac sodium, Fluazifop butyl, Fenoxaprop-p-ethyl etc.

7.8.2 Herbicide Application

The selected herbicide must reach the target part of plant to show its efficiency. Method of application is as important as the selection of proper herbicide. Herbicides are available with different formulations such as emulsifiable concentrates, granular, wettable powder, soluble liquid etc. which decides the application methods and equipments. Granular herbicides can be applied directly manually or using spreaders.Back pack knapsack hand pump or power sprayer are commonly used to spray herbicides. In big fields or farms, power sprayer, tractor mounted sprayer, drone sprayer will be more effective.

For herbicide application, flat fan or flood jet nozzles are recommended to get good results. Selecting the appropriate nozzle type based on the specific application needs can lead to improved results in weed management while minimizing environmental risks.

INTEXT QUESTIONS 7.6

1. State whether true (T) or false (F).

   a. Hand weeding is the cheapest way of weed management.

   b. Eradication is complete removal of all live plant parts and seeds of the weed from an area.

   c. Weed management during critical period of crop weed competition provides maximum yield and highest economic returns.

2. The herbicides which are applied after sowing the seeds but before emergence of weeds

   a. Post-emergence herbicides

   b. Pre-emergence herbicides

   c. Selective herbicides

   d. Pre-plant herbicides

3. Give one example of non-selective herbicide.

ACTIVITY 7.2

Imagine you are a consultant advising a farmer in a region facing water scarcity. The farmer is cultivating a variety of crops and is looking for an efficient irrigation system to optimize water usage and maximize crop yield. Propose a suitable irrigation system for the farmer, considering factors such as the type of crops, soil conditions, and available water resources.

....

....

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WHAT YOU HAVE LEARNT

- Plants take nutrients from soil, air and water in the form of ions, atoms or their simple molecules or compounds. There are 17 mineral elements essential for plant growth viz. Carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), Calcium (Ca), Magnesium (Mg), Sulfur (S), Boron (B), Chlorine (Cl), Copper (Cu), Iron (Fe), Manganese (Mn), Zinc (Zn), Molybdenum (Mo) and Nickel (Ni).
- Fertilizers are industrially produced chemicals which are rich in specific nutrients. Manures are organic in nature prepared from plant and animal residues.
- Bulky organic manures are FYM, compost, green manure while oilcakes, blood meal, meat meal, bone meal and fish manure come under concentrated manures. Bio-fertilizers are preparations containing live cells of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms used for application to seeds or soil.
- Right choice of fertilizers for crop production is crucial for ensuring good crop growth, higher profitability and soil health. Type of fertilizer, their method of application, time and dose are the important aspect of fertilizer management.
- Water is one of the key ingredients of life. Soil water is the major source of water for plant uptake. The artificial application of water to soil to supplement rainfall for crop production is called irrigation.
- The quantity of water required by a crop for its normal growth and development under a given field conditions is termed as water requirement of crops. It varies with types and duration of crop, soil types, climatic conditions and crop management practices.
- There are several surface and micro irrigation methods to apply water to the crop plants. Advanced irrigation techniques like sprinkler and drip method of irrigation are employed to improve the efficiency of irrigation.
- Weeds are unwanted or undesirable plants that compete with crops for water, soil nutrients, light, and space and thus reduce crop yields. The top layer of soil serves as vast reservoir of dormant and viable weed seeds.
- Weeds can be classified into annual, biennials and perennials based on life cycle, monocots and dicots depending upon the number of cotyledons present or grasses, sedges, and broad-leaved weeds based on their morphology.

- Various preventive and curative strategies have been employed to control weeds. Preventive measures are undertaken to prevent the entry of weed species in an area while several physical, mechanical, chemical and biological methods are combined in integrated weed management (IWM) technique for reducing weed infestation sustainably.

Notes

TERMINAL QUESTIONS

1. What is the 'criteria of essentiality'?
2. Describe in brief about various role and sign of deficiency symptoms of major macro nutrient elements.
3. Classify the various sources of plant nutrients along with their brief elaboration.
4. What is irrigation? Why is it necessary to irrigate the plants timely?
5. Differentiate between water requirement and irrigation requirement of crops.
6. Give a thorough description of different irrigation techniques.
7. What is weed? Classify them according to duration, morphology and number of cotyledons.
8. Explain critical period of crop weed competition.
9. Discuss different strategies for weed management.
10. Write a short note on following topics.
    a. Biological control of weeds
    b. Fertigation
    c. Beneficial nutrients
    d. Post-emergence herbicide
    e. Adhesion and cohesion

ANSWERS TO INTEXT QUESTIONS

7.1

1. 17
2. Option d (Iron)

3. Option a (Potassium)
4. False
5. Nitrogen

7.2

1. Option a (18%)
2. a. True b. False c. False

7.3

1. Irrigation is the artificial application of water to soil to supplement rainfall for crop production.
2. Option d (Irrigation)
3. a. False b. True
4. Option c (Sugarcane)

7.4

1. Check basin and furrow irrigation method
2. Drip irrigation
3. Drip irrigation

7.5

1. Weed
2. Chenopodium album
3. Option d (All of these)

7.6

1. a. False b. True c. True
2. Pre-emergence herbicides
3. Glyphosate/ Paraquat

Notes

GLOSSARY

Emulsifiable concentrates (ECs): This is a type of liquid herbicide where an active ingredient is dissolved in an organic solvent, combined with emulsifiers that facilitate the mixing of the concentrate with water to form a stable emulsion.

Evaporation: It is a process of transformation of liquid into gaseous state.

Percolation: The downward movement of water through soil is known as percolation. The gravitational force of earth provides energy for this process.

Seepage: It refers to lateral movement of water in soil. Through this process, water moves horizontally from the zone of higher potential to lower potential.

Soluble liquids (SLs): Soluble liquids are a type of pesticide formulation characterized by their ability to dissolve completely in water or polar solvents, creating a clear solution that can be easily applied.

Spreader: Spreaders are mixtures of mostly nonionic surfactants used for spreading and sticking a spray on plant leaves.

Transpiration: It is the process of evaporation of water from plant surfaces like leaf, stem or flowers.

Water potential: It refers to potential energy per unit quantity of water as compared to pure water. Generally pure water has zero water potential. Water potential measures the tendency of water to move from one area to another due to osmosis, gravity, pressure and matrix effects such as capillary action.

Wettable powder: It is a type of pesticide formulation where active ingredients are combined with wetting agents so that it can be mixed with water to create a suspension for spraying.

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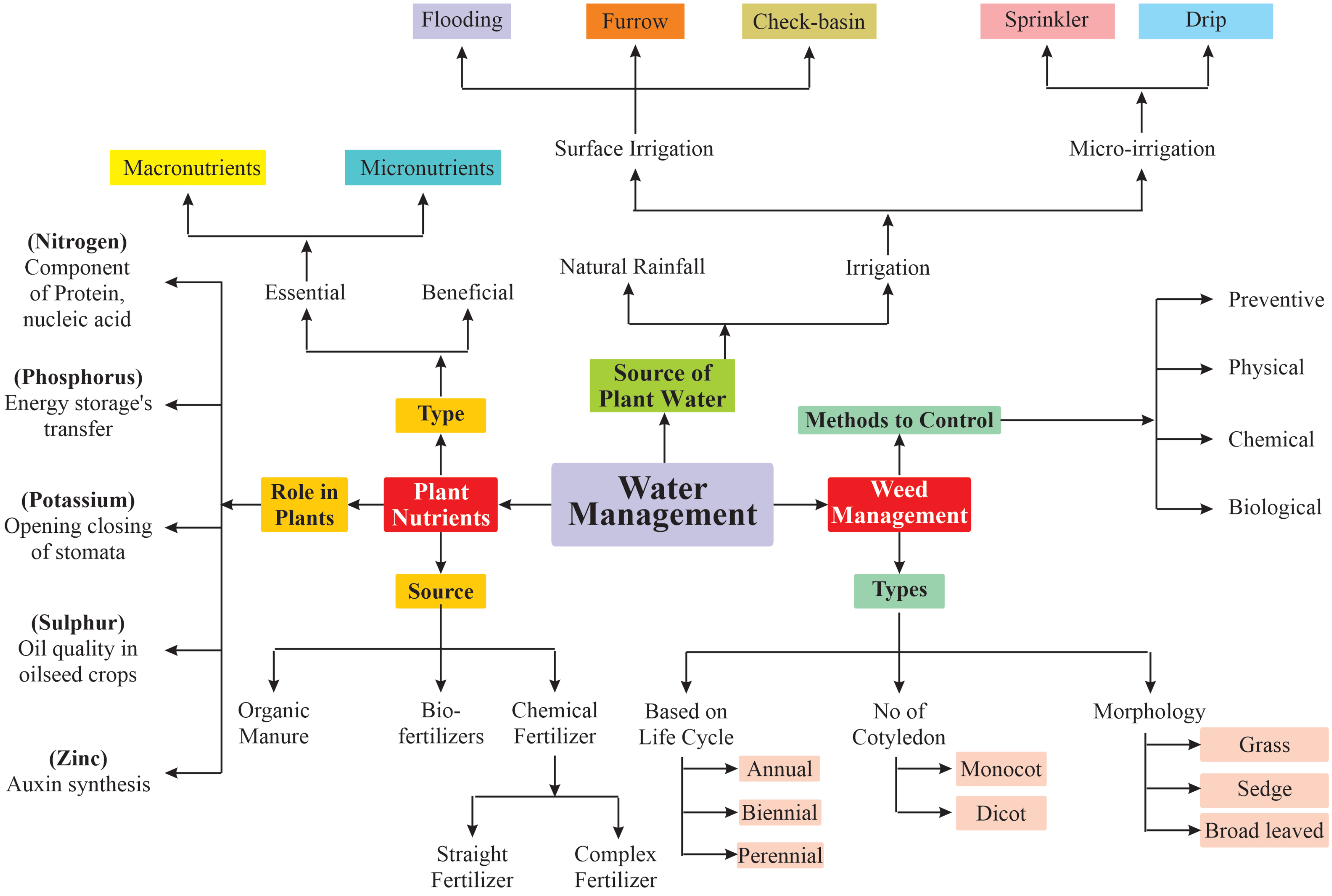
3. Reddy, T. Y. and Reddy, G. H. S. (2016). *Principles of Agronomy*, Kalyani Publishers, Ludhiana.

WHAT YOU HAVE LEARNT



NOTE

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PLANT PROTECTION AND HARVESTING

Plants are susceptible to bacteria, insects, fungi and other organism-induced infections, just like human bodies.Pests are tiny insects, animals, or even some types of parasitic plants that feed on crops, damaging them and making it unhealthy for consumption. Diseases in plants are usually caused by harmful bacteria, viruses, or fungi that spread through air, water, or soil, making the plants weak or sick. Successful harvest of agricultural produce depends heavily on the accurate detection and early prevention of these plant pathogens as well as proper timing and method of harvest. Learning about disease pests and harvesting techniques helps us to understand the importance of keeping our plants afresh, healthy and tasty so everyone can have enough to eat!

LEARNING OUTCOMES

After studying this lesson, the learner:

- defines the insects, pests, diseases and their life cycle;
- explains the importance of integrated pest management in managing ecological imbalance;
- distinguishes common disease symptoms of plants; and
- identifies the appropriate method and suitable time for harvesting of plant produces.

8.1 PEST MANAGEMENT

Agriculture production system is an ecosystem called agro-ecosystem comprising of interactive biotic and abiotic components. Plants, insects, macro and micro-organisms living in both above and below soil environment comprise the biotic components.

Notes

Abiotic components include soil, water, solar radiation, temperature, nutrients, and soil pH, etc. Forest, grassland, uncultivated waste lands, etc. are natural ecosystems wherein ecosystem functions operate naturally without human interference. On the contrary, agro-ecosystem is a 'managed ecosystem' where the producer manages resources and processes, restricting natural interaction among organisms. Ecosystem balance in agro-ecosystem is affected because of manipulation of system asfavourable cropsare being grown for maximizing productivity.

Plant's environment consists of some organisms which are beneficial to crop plants and some others are destructive. These harmful organisms damage the crop causing economic losses to farmers and are called as 'pests'. A pest may be any living organisms directly or indirectly causing economic losses to human and their belongings. Crop pests that include insects, diseases, weeds, nematodes, and rodents, etc. are the major constraints to the increased food grain production. However, such organisms may not assume the status of a pest in another place or season or year. The word pest though literally refers to insects, diseases, weeds, nematodes, rodents etc., but conventionally it is used for insects. It is important to understand the behavior, nature and biology of these organisms in order to manage these pests.

8.1.1 Insect-pests

Insect-pests are widely adapted and spread all over the agro-ecosystem of world. Insects belong to the class Insecta (true insects) under the phylum Arthropoda. The true insects along with mites belonging to the class Arachnida constitute most of the crop pests. The insect orders that are important to crop production are: Lepidoptera, Coleoptera, Hymenoptera, Diptera, Thysanoptera and Hemiptera. Study of certain life cycle, feeding habits and damage symptoms of insects are important principle of management strategy.

8.1.2 Life Cycle and Feeding Habit

Insect **life cycle** comprises of different stages of growth and development, from egg to adult. Those stages are egg, larva, pupa and adult. They pass through the process of gradual changes in shape from one stage to another, called **metamorphosis**. The type of metamorphosis is not same for insects of all orders. Young stage is named differently for different orders, such as larva, nymph, and naiad, etc.

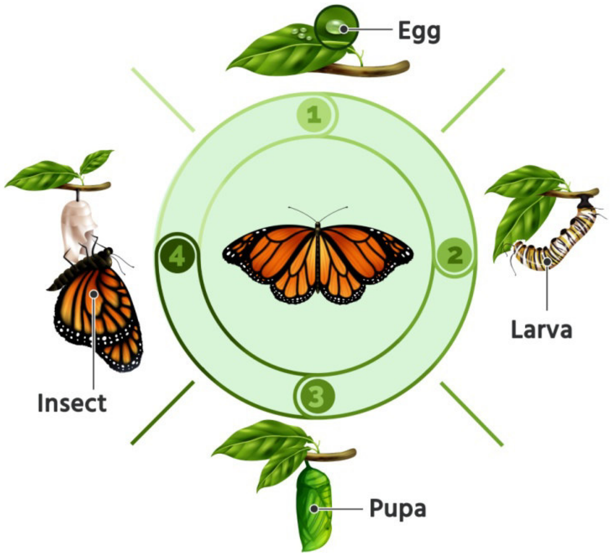

Fig. 8.1: Different growth stages of an insect

In accordance with the feeding behavior of the insects the damage symptoms are manifested.

1. **Chewing insects** chew during feeding with their chewing mouth parts. Insects belonging to this group are leaf folder, leaf miner, borers, tobacco caterpillar, semi-looper etc., leading to symptoms like defoliation, boring, and mining etc.

Fig. 8.2: Leaf mining and boring by chewing insects

2. Some other insects puncture plant tissues and suck saps during feeding which are called **sap feeders** with **piercing and sucking mouth parts**. These include aphids, mealybugs, plant hoppers, leaf hoppers, white fly and scale insects. Few of them act as vectors of viral diseases by transmitting them while sucking the sap. Symptoms are seen as yellowing, leaf curling, puckering, gall formation and deformation, etc.

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Fig. 8.3: Sucking of saps from plant tissues by white fly

INTEXT QUESTIONS 8.1

1. Which class do true insects belong to?

   a) Arachnida

   b) Insecta

   c) Crustacea

   d) Myriapoda

2. Which of the following insects is classified as a chewing insect?

   a) Aphids

   b) Mealybugs

   c) Tobacco caterpillar

   d) Whiteflies

3. State whether statement is true or false.

   a. Chewing insects primarily cause symptoms such as yellowing and leaf curling.

   b. Boring insects create tunnels in plant tissues, leading to structural damage.

8.2 INTEGRATED PESTMANAGEMENT

Chemical pesticides have no doubt played major role in controlling of insect-pests. However, their indiscriminate and inappropriate use by farmers in our agro-ecosystem since green revolution times has led to pest resistance, resurgence, problem residue retention and ecological imbalance by killing predators and parasitoids. A number of insect-pests management methods are used to minimize their incidence. These methods include physical, cultural, biological and chemical measures. No single method can achieve desired level of insect-pests control. Therefore, it was felt to integrate feasible methods which combinedly can prove more effective in managing the insect-pests. It led to the development of concept of Integrated Pest Management (IPM).

IPM is the careful selection and integration of all available pest control techniques that discourage the development of pest populations. It combines biological, chemical, physical and/or cultural management strategies and minimize the use of pesticides.The main principle of IPM is not to eliminate all the pests rather to manage their population to a level at which they do not cause significant losses. Prevention of entry of pests following good agronomic practices or cultural methods is given prime importance. Curative measures such as pesticides are only used when pest population reaches at economic threshold level (ETL). The **Economic Threshold** (ET) is the level of pest population at which control measures should be initiated to prevent the pest population from reaching the **Economic Injury Level** (EIL). EIL is the pest population level at which expected crop damage exceeds the cost of implementing control measures.An IPM strategy for pest management may include use of resistant varieties, modifying agronomic practices, biological control and other measures to reduce pest infestation and need-based and judicious use of pesticides.

A. Cultural Methods

These comprise of modification of agronomic management practices such that the crop environment becomes unfavourable for the growth of targeted pests. Some of those cultural practices are use of resistant varieties, summer ploughing, line sowing, adjustment of time of sowing or planting, bund trimming, crop rotation, weed control, field sanitation, and balanced fertilizer application, etc.

B. Physical Methods

Physical control methods include removal and destruction of egg masses, larvae, pupae and adults of insect-pests, use of traps for insects, rope dragging for dislodging leaf eating larvae, installation of bird perches in the field for sheltering birds to prey upon immature insects etc.

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C. Biological Methods

Biological control is based on the principle of employing natural enemies for the management of insects. It involves the use of living organisms or products derived from living materials to control pests. Different bio-agents like parasitoids, predators or pathogens are used to manage the insect population. Parasitoids are the organisms which lay eggs and complete their life cycles on host bodies as a result of which hosts die. Predators are the organisms which prey upon other organisms for their food. Predators may be different species of spiders, dragon flies, damsel flies, lady bird beetles, birds etc. Pathogens are micro-organisms such as fungi, viruses and bacteria which infect and cause diseases in their hosts as a result of which hosts are killed. These bio-agents can be mass multiplied in the laboratory in liquid or powdered formulations that can be sprayed like ordinary chemical pesticides. These formulations are known as bio-pesticides.

D. Behavioral Control

The behaviour of insects is controlled by the chemicals produced by insects to send signals to others over a large area. Sex pheromones can be used to confuse male insects and disrupt mating.

E. Chemical Control

A pesticide is designed to kill, control, repel, attract, or manage pests. They can be selective or non-selective. Selective pesticides are toxic to some species, with little or no effect on other species. Non-selective pesticides are toxic to a range of species. Here both beneficial and harmful organisms are harmed.

Use of chemical pesticides should be the last resort when all other methods fail to keep the pest population below economic loss. Therefore, use of pesticides should be need based, judicious, based on pest surveillance and economic threshold level (ETL) to minimize not only the cost involved, but also to reduce associated problems. While going for chemical control, we must understand thoroughly what to spray, when to spray, where to spray, how much to spray and how to spray.

DO YOU KNOW

People of India is practicing agriculture, animal husbandry, fisheries for thousands of years. Over this long period, Indian farmers have learnt to survive and grow food in difficult situations using natural products and practices. These knowledges are developed through careful observation and practical experience with nature. Such type of knowledge is termed as **Traditional Knowledge or Indigenous Technical Knowledge (ITK)**.

Indigenous agricultural systems often prioritize harmony with the environment, biodiversity conservation, climate adaptation and promotion of social and cultural value.Since traditional knowledge is primarily passed down orally, systematic documentation is essential for its preservation.In field of agriculture, such indigenous practices are available for pest management, soil and water management and rainwater harvesting. India is also a very rich sources of medicinal plants like ashwagandha, brahmi, kalmegh, aloe vera etc. Traditional knowledge of these medicinal and aromatic plants led to the development of **Ayurveda**, an alternative medicine system in Indian subcontinent.

INTEXT QUESTIONS 8.2

1. The Economic Threshold (ET) indicates the level of pest population at which control measures should be initiated to prevent reaching the __________.

2. Chemical pesticides have played a major role in controlling insect-pests, but their indiscriminate use has led to __________.

3. What is the main principle of biological control?

   a) Using chemical pesticides to eliminate pests

   b) Employing natural enemies for pest management

   c) Increasing the use of fertilizers

   d) Focusing solely on physical barriers

8.3 DISEASE PESTS

A disease interferes normal functioning of plants, resulting in a disrupted structure, growth, functions, or other parameters. Plant disease is defined as the state of local or

Notes

systemic abnormal physiological functioning of a plant, resulting from the continuous, prolonged 'irritation' caused by phyto-pathogenic organisms or environmental factors. **Infectious** plant diseases are mainly caused by pathogenic organisms such as fungi, bacteria, viruses, nematodes and protozoa. Such diseases spread from one susceptible host to another, since the infectious agent can reproduce in the plant or on its surface.

Plant diseases are also **non-infectious,** caused by unfavorable abiotic factors such as adverse soil and environmental conditions. Since pathogens are not involved, they are not transmitted from a diseased plant to a healthy one.

8.3.1 Pathogens and Disease Symptoms

Microorganisms which have ability to cause plant diseases with development of symptoms are called pathogens. Causative organism may be fungi, bacteria, viruses, protozoa or nematodes. The external or internal reactions or alterations of a plant as a result of a disease are manifested as symptoms specific to the disease. The symptoms of the disease may depend on its cause, nature, and the location of the impact site.

A. **Fungi**: Fungi are spore forming, non-chlorophytic, eukaryotic organisms; some of them are parasitic fungi causing diseases in crop plants. Fungal parasites are by far the most prevalent plant pathogenic organisms. Fungi are found in all ecological niches and can cause significant damage. The important symptoms of fungal diseases are illustrated in figure 8.4.

Table 8.1: Common disease symptoms of plants

Name of disease	Description
Wilting	Loss of cell turgidity
Leafspot	Spot or lesions on leaf or stem due to necrosis of invaded cells
Anthracnose	Ulcer like lesion that can be necrotic and sunken
Canker	Localized necrotic lesion on woody tissue
Dampingoff	Collapse and death of very young seedlings
Scab	lesion on tubers and other plant parts
Blight	Browning and death of leaves
Rusts	Many small lesions on stems or leaves giving rust appearance
Dieback	Progressive death of shoots generally starting at the tip
Powdery and downy mildews	Formation of mycelium, fruiting bodies and necrotic tissue

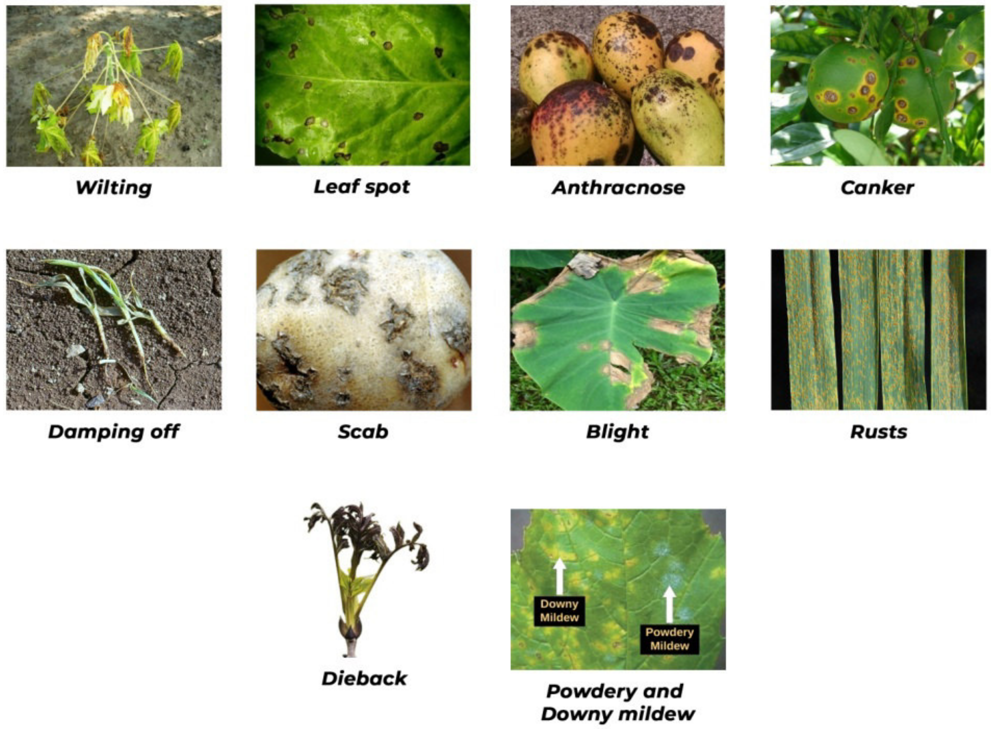


Fig. 8.4: Common disease symptoms of plants

B. **Bacteria**: Bacteria are microscopic, single-celled prokaryotic organisms, without a defined nucleus, that reproduce asexually by binary fission (one cell splitting into two). They occur singly or in colonies of cells. Symptoms of bacterial infection in plants are much like the symptoms in fungal plant disease. They include leaf spots, blights, wilts, scabs, cankers and root rot, fruit rot and overgrowth.

C. **Viruses**: Viruses are non-cellular infectious agents that need a host tissue to stay alive (i.e. obligate parasites). Unlike true animals they are incapable of digestion and respiration. Viruses consist of nucleic acid, either RNA or DNA at the core protected by a protein coat called capsid. Viruses infect all types of organisms, from plants and animals to bacteria. Most of plant viruses are RNA viruses. Sucking insects like aphids and chewing insects such as thrips transfer viral diseases from infected plants to healthy ones through feeding. Such insects are called as vectors. Besides insects, certain mites, nematodes, and fungi also transmit plant viruses. The symptoms of viral diseases can be of different types, such as growth suppression (reduced growth of the entire plant or its leading shoots), discoloration (mosaic, chlorotic rings, leaf chlorosis, and variegation), deformations (leaf wrinkling, corrugation, thread like leaves), necrosis and impaired reproduction (flower sterility, parthenocarpy, shedding of flowers and ovaries).

Notes

Fig. 8.5: Leaf mosaic and leaf curling due to viral infection

8.3.2 Disease Management

Pesticides are also given major importance for control of plant diseases like insecticides. Fungicides and antibiotics are used as curative measures for control of fungal and bacterial plant diseases. Vector management is the first line defense for control of viral diseases.

Management of diseases through integrated approach is also applicable to manage plant diseases. It focuses on long term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, and modification of cultural practices and use of resistant varieties.

Management of pathogen involves the practices directed to exclude, reduce or eradicate inoculums. Management of the host involves the practices directed to improve plant vigor and induce resistance through nutrition, introduction of genetic resistance through breeding and providing need based protection by chemical means. Management of environment involves the practices that modify the environment which is not favorable to pathogen or disease development and does not predispose host to attack.

? DO YOU KNOW

Before the discovery of chemical pesticides, different plant and animal-based materials were commonly used for agricultural pest and disease management in India. These materials are eco-friendly in nature and include neem, turmeric, tulsi, salt, lime solution, castor oil, mustard oil, cow dung, cow urine, ghee, lemon, methi, *bael*, curd, asafoetida, mintetc. Apart from pest management, they have other utilities also. Out of these materials, neem (*Azadiracta indica*) is most famous for its anti-microbial properties. Various types of neem-based bio-pesticides (e.g., Vijay Neem) and fertilizers (e.g., neem coated urea) are available in market.

1.	Neem	Neem-seed extract is used for controlling insect pests of cotton, pigeonpea and chickpea. Neem cake is used for control of termite and early stem borer in rice.
2.	Turmeric	Used for storing rice seed and curing injuries of animal
3.	Cow dung	Used for increasing organic matter content in soil, seed treatment of desi cotton and wilt control in ginger
4.	Cow urine	Used to manage smut disease in sorghum, termite attack in wheat
5.	Ash	Used for supplying potassium in soil and controlling root disease in fruit trees
6.	Tobacco	Control of white fly in cotton and leaf spot in banana
7.	Lime solution	Used for better germination of groundnut and control of white grub
8.	Salt	Used to control weed, khaira and blast disease in rice field

(Source: Handbook of Agriculture, ICAR, New Delhi)

INTEXT QUESTIONS 8.3

1. Which fungal disease is characterized by ulcer-like lesions that can be necrotic and sunken?

   a) Canker

   b) Scab

   c) Anthracnose

   d) Blight

2. The fungi are classified as?

   a) Prokaryotic

   b) Eukaryotic

   c) Chlorophytic

   d) Non-spore forming

3. Fungi are chlorophytic organisms that can photosynthesize (True/False).

4. Most plant viruses are classified as __________ viruses.

Notes

ACTIVITY 8.1

You must have some favourite plants at your home garden or near playground. Suppose you are on a mission to protect your favourite plants from attack of pests. But you can not apply chemicals here because it may kill the other friendly insects living in the garden. Use your creative thinking and knowledge to design an insect pest management plan for the environmentally safe garden.

....

....

....

....

8.4 HARVESTING

The economic parts of the crops need to be harvested by the farmer to earn the profit from the crop production enterprise. The process of removal of economic parts or the whole plant at right maturity is called harvesting. The economic parts may be grain, stem, leaf, root, flower or the whole plant. Crop must be harvested at right time, by right method and stored in right way for obtaining maximum profit from market. Crops are harvested when they are considered as 'mature'. Two types of maturity used by scientists are physiological maturity and harvest maturity.

I. **Physiological maturity:** It refers to the stage of the crop growth when the plants reach maximum dry weight. Application of inputs at this stage does not produce additional yield. In grain crops it relates to hard dough stage where grain moisture content will be around 40%. If crop is harvested at this stage, the grain will shrivel upon drying lowering the quality of produce.

II. **Harvest maturity:** It refers to the stage when the grain or respective economic part is at highest quality and quantity. In rice, the crop is harvested when grain moisture content is between 20 and 25%. When grain squeezed between the teeth it should feel firm but not brittle.

Notes

8.4.1 Criteria for Harvesting of Crops

The right time to harvest a crop depends on the economic part, use of the product and post-harvest operations. The maturity indicator and criteria of harvesting of few major crops are given in table 8.2.

Table 8.2: Criteria of harvesting for different agricultural crops

Crop	Harvesting criteria
Rice normally	80-85% of the grains are straw colored (yellow coloured); occurs at 30-35 days after heading stage
Wheat	Hard dough stage, Yellowing of spikelets and straw becomes dry
Maize grain	Husk turns pale brown in colour, 25 to 30 days after tasseling, moisture level is between 20-25%
Sorghum	40 days after flowering, grain moisture content is less than 28%, yellow coloured ears with hard grains
Finger millet	Brown coloured ears with hard grains
Chickpea	Leaves dry up and shedding starts, plants turn reddish brown
Pigeonpea	35-40 days after flowering, 80-85% of pods turn brown
Greengram and blackgram	Pods turn brown or black, dried pods with hard seeds inside
Groundnut	Yellowing of leaves, dark coloured patches inside the shell, kernels turn red or pink
Rapeseed-mustard	75-80% siliqua turn yellow, seed moisture content at 30%, seeds are firm if pressed between fingers
Sugarcane	Drying of lower leaves, brix between 18 to 20%, sucrose about 15%
Cotton	Well dried and fully opened bolls

8.4.2 Harvesting Methods and Processes

Harvesting of field crops comprises of sequence of operations which can be done in individual steps or in combination mechanically. These include reaping, drying, threshing,

cleaning and bagging. Harvesting may be carried out manually or mechanically using machines. Manually harvested produce maintains better quality and fetches premium prices, whereas mechanical harvesting should be performed when grain reaches right moisture content. Manual harvesting is carried out with sickle which is tedious and labour intensive. Mechanical harvesting may either be accomplished at different steps such as reaping the crop using power reaper and threshing with axial flow thresher or electrical thresher. On the other hand, several operations can be carried out at a time in combine harvester machine. It performs multiple processes of reaping the crop, threshing and cleaning the produce in one pass.

Reaping: It is the process of cutting the mature crop about 10-15 cm above ground. Left over portion of the crop is called as stubble. For manual operation, sickles are usually used whereas mechanically it is done through power reapers.

↓

Field drying: Here the cut crop is left in the field, exposing it to the sun for drying. It is conventionally followed when crop is harvested manually. When combine harvester machine is used, drying is done after threshing. Besides sun drying, different other types of driers are also used for this purpose.

↓

Threshing: Here grains are separated from the reaped crop. Traditionally farmers thresh the harvested crop by beating the bundled crop against wooden or bamboo made structures. Now-a-days, human operated, electrical threshers and tractor operated axial flow threshers are being used.

↓

Cleaning: Chaffy (unfilled) grains, half-filled grains, non-grain materials or trashes and dust are removed through the process of winnowing. A blower or an air fan can be used to remove lighter impurities. However, larger sized stones and smaller weed seeds as mixed with grains can be removed through sieves or screens of different sizes.

↓

Bagging: Finally, the threshed and clean grain is put in bags for transport or for safe storage.

The farmer utilized farm machine & tools in the vedic period.The tools '*srni*' and '*datra*' (sickle) was usedfor harvesting in Rigveda period.*Khanitra* (shovel) was used for digging of soil. The vedic people also record the use of '*surpa*' for winnowing of paddy and barley.

After successful harvesting of grains, farmers often select good and healthy seeds to store them for next season. Generally, astorage structure, i.e. bin, is used for long-term storage of grains. In Tamil Nadu, atthe time of seed storage, leaves of notchi (*Vitex negundo*), neem(*Azadirachta indica*)and pungam (*Pongamia pinnata*)are mixed. Apart from mixing, afew leaves are spread at the top ofseeds. On the top of it, wastepaper andpaddy straw are spread to cover thesurface. This practice helps to prevent pest attack.Pulse grains are stored ingunny bags after coating with mixture of red soil and leaf extract of malai vembu (*Melia azadirachta*) and thumbai(*Leucas aspera*). People in north Goa use a special type of bamboo structure called '*Tatho*' for storage of rice grain.

Notes

INTEXT QUESTIONS 8.4

1. Stage of crop growth where plant reaches maximum dry weight is termed as
   a. Harvest maturity
   b. Physiological maturity
   c. Crop maturity
   d. Field maturity
2. Sugarcane is harvested at brix rating of
   a. 18-20
   b. 10-14
   c. 23-25
   d. 0-5
3. What is reaping?
4. Define threshing.

Notes

WHAT YOU HAVE LEARNT

- A pest is any living organism which is directly or indirectly causing economic losses to human and their belongings. Crop pests include insects, diseases, weeds, nematodes, and rodents etc.
- Insect life cycle undergoes different stages of growth and development namely egg, larva, pupa and adult. This gradual change in shape and size is called metamorphosis.
- Various insects have unique feeding habits like leaf folder, borers chew the leaves while aphids,white fly and plant hoppers suck the plant sap from leaves.
- Several physical, chemical and biological methods are employed to control pests. Integrated Pest Management (IPM) is a novel technique where all available pest control techniques are integrated to discourage the development of pest populations so that they can't reach the Economic Injury Level (EIL).
- Infectious plant diseases are mainly caused by pathogenic organisms such as fungi, bacteria, viruses, nematodes and protozoa.Non-infectious plant diseases are caused by unfavorable abiotic factors such as adverse soil and environmental conditions.
- Plant disease management involves a variety of strategies to prevent, identify, and control diseases affecting plants. These methods include exclusion, reduction or eradication of inoculums, plant vigor improvement, induction of resistance through nutrition, and introduction of genetic resistance.
- Crop must be harvested at right time, by right method and stored in right way for obtaining maximum profit from market. Each crop should be harvested following the specific harvest criteria.
- Harvesting can be done either manually or mechanically with machines. Although manually harvested crops tend to maintain higher quality, it is labor-intensive and time-consuming process. Mechanical harvesting should occur when the grain has reached the appropriate moisture content.

TERMINAL QUESTIONS

1. Define agro-ecosystem and its components. Differentiate between natural ecosystems and agro-ecosystems.

2. Discuss the life cycle of insect pests.

3. Classify insects according to their feeding habit. Give suitable examples along with it.

4. Explain the concept of Integrated Pest Management (IPM) and its significance in agriculture.

5. Compare selective and non-selective pesticides. What are the implications of their use?

6. Define plant disease and explain the difference between infectious and non-infectious plant diseases.

7. What are pathogens? List the major types of pathogens that cause plant diseases.

8. How do viruses cause diseases in plants? Explain their mode of transmission and common symptoms.

9. Illustrate the typical symptoms of fungal and bacterial infection in plant.

10. How do you differentiate between physiological maturity and harvest maturity?

11. Mention the criteria of harvesting for following crops.

    a) Cotton

    b) Maize

    c) Wheat

    d) Groundnut

    e) Chick pea

ANSWERS TO INTEXT QUESTIONS

8.1

1. Insecta (option b)
2. Tobacco caterpillar (option c)
3. a. False, b. True

8.2

1. Economic Injury Level (EIL)
2. Pest resistance, resurgence, and ecological imbalance
3. Employing natural enemies for pest management (Option b)

8.3

1. Anthracnose (option c)
2. Eukaryotic (option b)
3. False
4. RNA

8.4

1. Physiological maturity (Option b)
2. 18-20 (Option a)
3. It is the process of cutting the mature crop about 10-15 cm above ground.
4. It is process of separation of grain from reaped crop.

GLOSSARY

Ecological Niche: It is sum of all activities and relationships of a species by which it uses the resources in its habitat for survival and reproduction. Therefore a niche comprises of habitat (where organism lives), function played by it and interrelationship with other organisms.

Ecosystem: An ecosystem is a functional unit of nature encompassing complex interaction between its biotic (living) and abiotic (non-living) components. For example- a pond is a good example of ecosystem.

Mite: A mite is a small arachnid belonging to the class Arachnida. These creatures are characterized by their eight legs and can be found in various habitats, including soil, plants, animals, and even indoor settings such as carpets and bedding.

Nematode: Nematodes are commonly known as roundworms or eelworms. They belong to the phylum Nematoda and are characterized by their unsegmented, cylindrical, and elongated with a tapered body shape.Many species are important parasites of plants and animals,whereas others are beneficial to agriculture and the environment. One such plant parasitic nematode is root-knot nematode (*Meloidogyne* spp.) which causes root gall in plants.

Pest Resistance: It occurs when a population of pests evolves to become less susceptible to a pesticide that was previously effective.

Pest Resurgence: It is a phenomenon of reappearance pest populations after an initial decline due to pesticide application. Here pest reappears with higher density than initial population due to destruction of its natural enemies.

Sex Pheromone: Pheromones are chemical substances secreted by organisms that trigger specific behavioral responses in other individuals of the same species. They are distinct from hormones, which act within the body, as pheromones are released into the environment to communicate with others. Sex pheromones are released to attract individuals of the same species for mating purposes.

SUGGESTED READINGS

1. *Crop pests & stored grain pests & their management*, e-KrishiShiksha, Agricultural Education Division, Indian Council of Agricultural Research, New Delhi (https://ecourses.icar.gov.in/).

Notes

2. *Diseases of field crops and their management*, e-KrishiShiksha, Agricultural Education Division, Indian Council of Agricultural Research, New Delhi (https://ecourses.icar.gov.in/).

3. Reddy, T. Y. and Reddy, G. H. S. (2023). *Principles of Agronomy*, Kalyani Publishers, Ludhiana.

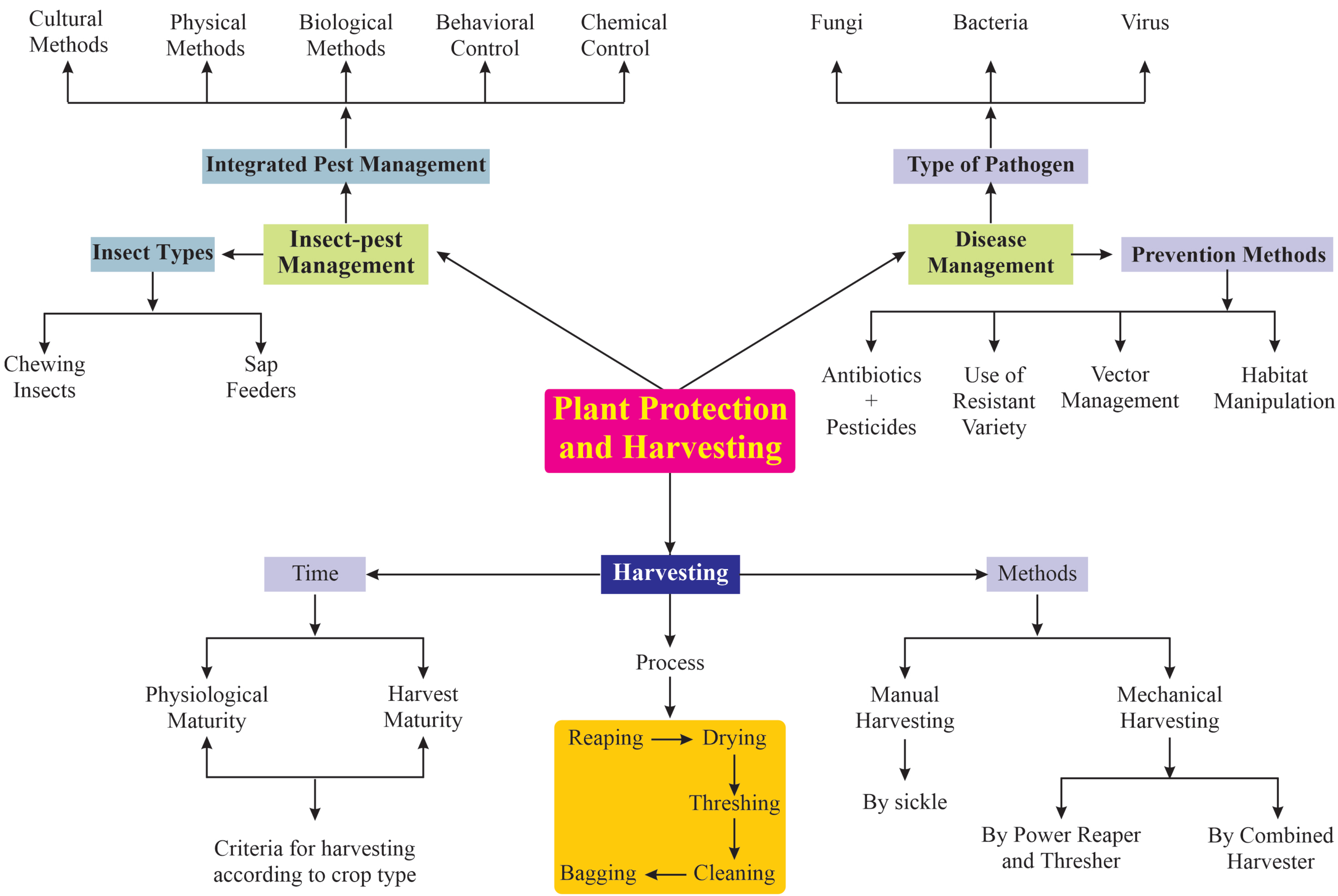
If you want to know more about indigenous agricultural practices, you may visit the following resources

i. https://vedicheritage.gov.in/vedic-heritage-in-present-context/agriculture-2/

ii. https://icar.org.in/ITK

iii. Mishra, Anupam, Singh, S.R.K., Raut, A.A. (2020). Traditional Knowledge in Agriculture.Division of Agricultural Extension, ICAR, New Delhi. Pp.39.

WHAT YOU HAVE LEARNT



NOTE

9

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FUNDAMENTALS OF HORTICULTURE AND FRUIT PRODUCTION

In the previous lessons we have discussed about different agricultural practices. The same practices of agriculture are also applied in cultivation of fruits, vegetables and flowers. The scientific cultivation of these crops is studied under the field of horticultural science. Horticulture is a branch of agricultural science which primarily deals with cultivation of fruits, vegetables, plantations, spices & condiments, ornamentals, medicinal and aromatic plants. Horticulture sector provides immense opportunities for crop diversification, nutritional security, livelihood security through employment and income generation. Our country earns huge amount of foreign reserve through export of fruit, vegetable, spices and floriculture products. In this lesson, we will learn about various horticultural terms and techniques for efficient production of horticultural commodities.

LEARNING OUTCOMES

After studying this chapter, the learner:

- defines the concept and origin of horticulture;
- identifies the different horticultural zones of India;
- describes various plant propagation techniques;
- discusses about orchard for large scale production of fruits; and
- explains the causes and remedies of fruit barrenness.

9.1 HORTICULTURE: CONCEPT & ORIGIN

The term 'Horticulture' originates from two Latin words i.e. *Hortus* (meaning - garden) and *Cultura* (meaning - cultivation), combining which horticulture stands for cultivation

Notes

of garden crops like fruits, vegetables and flowers. But in present condition, it also includes plantation crops, spices, condiments, decorative indoor plants, landscape plants, medicinal and aromatic plants. India is the second largest producer of fruits and vegetables after China. Horticultural produces are highly perishable in nature and require special care to meet consumer satisfaction.

Origin of horticulture dates back to a time when hunter-gatherer people transformed their nomadic life to settled communities when people began to collect and plant the seeds of various nuts and fruits for their own purpose. It is believed that since Neolithic age, agriculture and horticulture were coevolved till the middle age. Egypt is considered as birthplace of modern horticulture. Ancient temple gardens of Egypt had grapevine, palm and fruit trees and they incorporated modern features of gardening like formal layout, systemic irrigation systems, container gardening, various level of gardens and different section within a garden. The Greeks and Romans further advanced horticultural knowledge through writings on agriculture and techniques such as crop rotation and grafting. Horticulture has also cultural and religious significance in addition to being a means of subsistence. For example, gardens in ancient civilizations often had symbolic meanings and were associated with deities or used in rituals. Today, horticulture encompasses various branches reflecting its broad scope beyond mere food production.

INTEXT QUESTIONS 9.1

1. Horticulture is a .... word.

2. Fruit and vegetables have longer shelf life (True/False).

3. Which is considered as birthplace of modern horticulture?

   a. India   b. Greece

   c. China   d. Egypt

9.2 IMPORTANCE OF HORTICULTURAL CROP

a) Horticultural crops specially fruits and vegetables are rich source of vitamin, mineral, fibre, carbohydrate, protein and fats. Hence, such crops are called protective foods. These nutrients are very essential for normal functioning and maintenance of human health.

b) Fruits, vegetables and flowers often fetch high price in market in comparison to food grain crops. Cultivation and marketing of such crops have huge potential to provide good profit to owners and contribute in national economy.

c) Many horticulture-based complementary industries like storage, canning and food processing can be developed if horticultural production gains momentum in country. These industries create lot of employment opportunities for the people, particularly youth.

d) Continuous cultivation of same type of crops (rice or wheat) years after years deteriorates soil health and increases the chances of frequent pest and diseases attack. Inclusion of horticultural crop in crop cycle can effectively mitigate such hazards in long-term.

INTEXT QUESTIONS 9.2

1. What is protective food?

2. Horticultural crops are sold at higher prices in market (True/False).

9.3 DIVISION OF HORTICULTURE

I. Pomology

Pomology is derived from Latin words i.e. '*Pomum*' meaning fruit and '*Logos*' meaning discourse or study. Hence it is scientific study of fruit crops like mango, banana, guava, litchi, pomegranate, jamun, sapota etc.

II. Olericulture

The term 'Olericulture' is derived from Latin words i.e. '*Oleri*' meaning vegetable and '*Cultura*' meaning cultivation. Hence, olericulture means scientific cultivation and management of vegetable crops like potato, tomato, brinjal, okra, chilli etc.

III. Floriculture

The floriculture refers to scientific cultivation of flowers (rose, jasmine, lotus, gladiolus) and ornamental crops (areca palm, peace lily, snake plant, christmas tree).

IV. Spices, Plantation, Medicinal & Aromatic crops

a. Spices – These are used to season the food for aroma and flavor. E.g., Pepper, Cardamom and Clove

b. Condiments – Food adjuncts that are used for enhancing taste only. E.g., Coriander and Cumin.

c. Medicinal plants – Plants which are rich source of secondary metabolites and have medicinal as well as therapeutic properties. E.g., Tulsi, Ashwagandha, Kalmegh.

V. Arboriculture

It is the science of growing perennial trees for natural, aesthetic or scientific study purpose. E.g. Ashoka tree, Arjun and Neem etc.

VI. Post-harvest Technology (PHT)

PHT is the application of scientific principles and technologies to agricultural products after harvesting from farms for preservation, processing, packaging, storage, handling, transportation, and marketing i.e., jam, jelly and pickles etc.

INTEXT QUESTIONS 9.3

1. Pomology is a science of

   a. Vegetable b. Fruit

   c. Flower d. Spices

2. Which division of horticulture has crops like potato, tomato and brinjal?

3. Give examples of two medicinal plants.

4. Science of growing perennial trees is known as …………..

9.4 CLIMATIC ZONES FOR HORTICULTURAL PRODUCTION IN INDIA

India is classified into following six horticultural zones based on regional diversity in soil and climate and the states covered therein:

1. **Temperate**: Kashmir, Himachal Pradesh, Sikkim, parts of Uttarakhand and Arunachal Pradesh.

2. **Central Tropical**: Chhattisgarh, Odisha, West Bengal, Gujarat, Maharashtra, southern Madhya Pradesh

3. **Southern Tropical**: Tamil Nadu, Karnataka, Telengana, parts of Andhra Pradesh

4. **North Eastern Subtropical**: Manipur, Meghalaya, Nagaland, Assam, Bihar and Jharkhand

5. **North Western Subtropical**: Rajasthan, Punjab, Haryana, northern part of Madhya Pradesh and central part of Uttar Pradesh

6. **Coastal Tropical Humid**: Kerala, Goa, Eastern Ghats of Tamil Nadu, Konkan, coastal areas of Andhra Pradesh and Odisha

INTEXT QUESTIONS 9.4

1. How many horticultural zones are there in India?

2. State of Kashmir and Himachal Pradesh comes under the horticultural zone of

   a. Southern tropical

   b. North western subtropical

   c. Temperate

   d. Coastal humid

3. Major North eastern states of India are placed at …………….. horticultural zone.

9.5 FACTORS AFFECTING HORTICULTURAL PRODUCTION

Factors of horticultural production can be grouped into biotic and abiotic factors based on their origin.

1) **Biotic factors:** These are originated from biological sources of nature. Examples of such factors are crop variety, weeds, insects, pathogen and nematodes.

   a. **Crop variety:** Different crop varieties have different requirement for climate, soil and nutrients for their optimum growth and yield. Therefore, selecting right variety is crucial in achieving good horticultural yield.

Notes

b. **Weeds:** These are unwanted crops grown in horticultural field. If such plants are not controlled properly, they can compete with main crop plant for essential nutrients, water and solar radiation and cause reduction in yield to main crop.

c. **Insect-pests:** Insect and nematode feed on plants through sucking, chewing, biting and boring leaves, stems, fruits and roots. Thus, they lower the economic yield and value of plant produce.

d. **Pathogen:** Fungi, viruses, bacteria and phytoplasma causes diseases in crop plant and affect crop yield. Their timely management can improve crop yield.

2) **Abiotic factors:** These are the factors which are not biological in nature such as climate, water, light, soil condition, intercultural operations, and quality input materials.

a. **Climate:** Plant can be successfully grown if optimum environmental conditions are maintained during their life cycle. Plant can't tolerate extreme condition of rainfall, temperature, humidity, storm or solar radiation which can affect crop yield or sometimes cause total crop failure.

b. **Water:** Water is essential for plant growth and crop yield. Horticultural crops have prominence of water content and its role starts from seed germination. Therefore, availability of water as per plant demand is critical for successful plant establishment which may be met through rainfall or irrigation.

c. **Soil condition:** Soil texture (sand, silt, clay) and composition (organic matter, minerals) affect water retention, drainage, and nutrient availability. The pH of the soil influences nutrient solubility and microbial activity. Different crops thrive in different pH ranges.

d. **Light:** Intensity and duration of light are important factors essential for photosynthesis. Insufficient light can limit plant growth, while too much light can cause stress. In photoperiod-sensitive plants, flowering is also be influenced by day length.

e. **Intercultural operations**: Crop yield can be improved dramatically if there is timely operations (training, pruning, hoeing, earthing up) of intercultural practices.

f. **Quality inputs:** If inputs such as seeds, planting materials, irrigation water, manures and fertilizer, pesticides are sub-standard, they can affect both crop quality as well as quantity.

Notes

INTEXT QUESTIONS 9.5

1. Non biological factors of production are termed as ……………..

2. Which of the following is biotic factor of production

   a. Weed   b. Pest

   c. Crop variety   d. All of these

3. What is photoperiodism?

9.6 PROPAGATION OF HORTICULTURAL CROPS

Plant propagation is a technique of multiplication of plants intended for specific purpose. Broadly they are of two types – a) asexual propagation and b) sexual propagation.

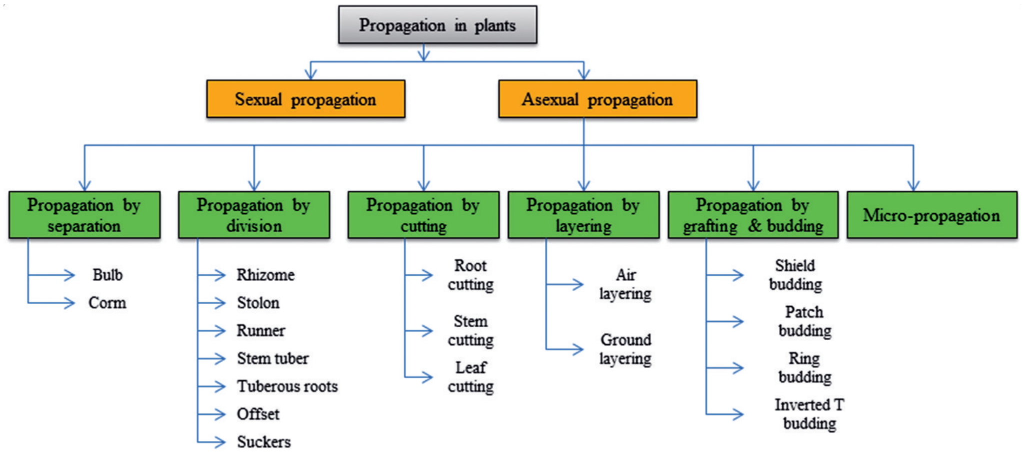

Fig. 9.1: Different propagation methods of horticultural plants

9.6.1 Asexual Propagation

Asexual propagation is reproduction by means of vegetative parts of a plant such as roots, shoots, or leaves other than seed.

Advantages

- Through this method of propagation, true-to-type of plants can be developed without any changes in the genetic makeup of the plant.

Notes

Disadvantages:

- This propagation technique does not allow the development of new varieties.

Types of Asexual Propagation:

Some plants produce specialized vegetative structures which may be removed from parent plant and used as propagation materials. These vegetative structures are bulb, corm, rhizome, tuber, stolon, runner etc.

1. **Plant Propagation through Separation**: It is a method of propagation where vegetative structures from parent plant are collected as such and planted in soil for germination. Such structures are separated from plant body by breaking at their natural lines. Two such specialized sub surface structures bulbs and corms.

   a. **Bulbs**: It is a unique subsurface organ made of fleshy leaf scales that are attached to a stem tissue called basal plate. These are of two types:

      i. **Tunicate**: Here outer bulb scales are dry and membranous. Such fleshy scales are found in continuous, concentric layers therefore the structure of bulb is more solid. E.g. Onion.

      ii. **Non-tunicate (scaly) bulbs:** These bulbs lack the dry, enclosing coating. Here the scales are separate and joined with the basal plate. Scales can be individually removed from the bulb since they are loose. Non-tunicate bulbs often require greater care to handle since they are more prone to damage than tunicate bulbs. E.g. Gladiolus, Lily.

Fig. 9.2: Tunicate and non-tunicate bulbs

   b. **Corms:** These are modified stems possessing short internodes where food is stored. They are tightly covered with scaly, dry leaves. New shoots are sprouted out from corms with the help of stored food. E.g. Amorphophallus, Colocasia, and Gladiolus.

Fig. 9.3: Corms

2. **Plant Propagation through Division:** It is a method of plant propagation where vegetative structures are divided into several cut sections and each section will give rise to new plant.

   a. **Rhizome:** The primary axis of a plant develops horizontally just below or on the surface of the ground in a stem structure known as a rhizome. E.g. Ginger, Bamboo, Canna.

   b. **Stolon:** It is a term used to describe various types of horizontally growing stems that produce adventitious roots when come in contact with the soil. E.g. Mint, Bermuda grass.

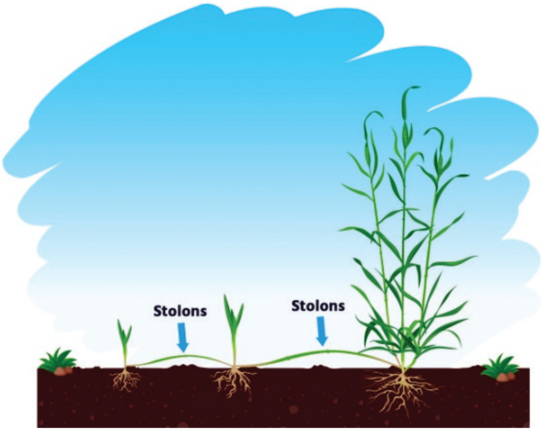

Fig. 9.4: Stolons

   c. **Runner:** This is a specialized form of stem that develops from the leaf axils at the crown region of a plant, grows horizontally and runs along the ground to form a new plant from a node. E.g. Strawberry, Oxalis, Blue berry etc.

Notes

Fig. 9.5: Runner of Strawberry

d. **Stem tuber:** A tuber is specialized swollen underground stem stored with full of starch having eyes in regular order over the surface. E.g. Potato.

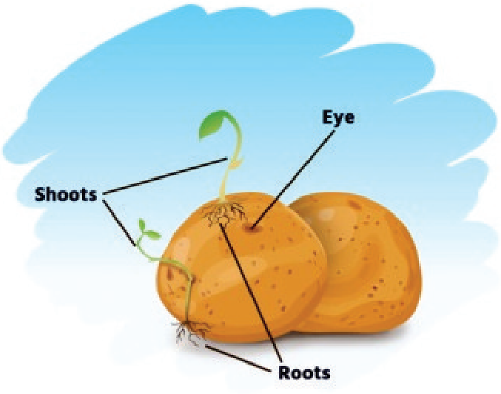

Fig. 9.6: Stem tuber of potato

e. **Tuberous roots:** These are thickened tuberous growth that functions as storage organs. E.g. Dahlia, Begonia, Sweet potato.

f. **Offset:** It is a short thickened horizontal branch growing out of the crown ending at the apex with a tuft of leaves and a cluster of leaves below. E.g. Pistia, Agave and Water hyacinth.

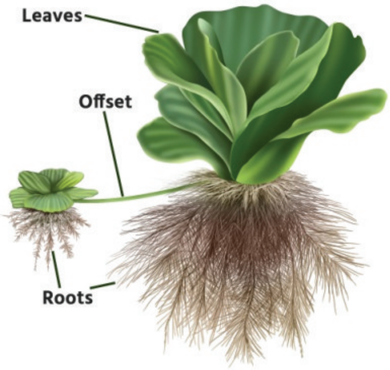

Fig. 9.7: Offset of Pistia

g. **Suckers:** It is a lateral branch developing from the underground parts of the stem or roots. There are two types of suckers:

i. **Shoot suckers:** These will arise from the base of the stem. E.g. Banana, Pineapple.

ii. **Root suckers:** The root suckers will arise from the adventitious buds on the roots. E.g. Guava.

3. **Plant Propagation by Cuttings:** This is one of the easiest and most popular method of plant propagation. A cutting is a portion of a stem, a leaf or part of a leaf, a piece of a root, or even a scale from a bulb from where new plant regenerates itself.

Different types of cutting are

a. **Root Cutting:** New plants are developed from root cutting of plants.

b. **Stem Cutting:** New plants are developed from stem cutting of plants.

c. **Leaf Cutting:** In some plants leaves have capacity to produce roots. New plants are developed from leaf of such plants.

4. **Plant Propagation by Layerings:** Layering is the process of inducing roots on lateral branches while it is still attached to the parent plant. This method is simple and does not need regular care and management compared to cutting. It can be classified into air layering (gootee/marcottage) and ground layering.

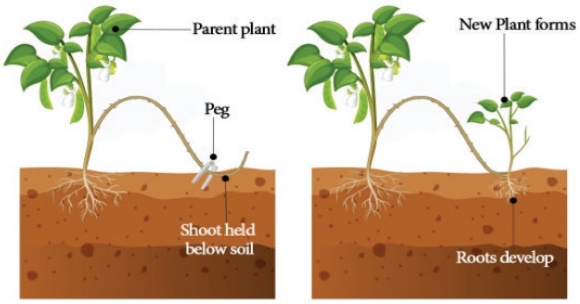

Fig. 9.8: Plant propagation through layering

5. **Plant propagation through Grafting and Budding:** Grafting is the art of uniting pieces of two separate plants (upper part – scion and lower part - stock) so that they come together by union of cambial cells and develop into a single, independent plant. In budding, bud from a plant is removed and fixed for growing as new plant.

Notes

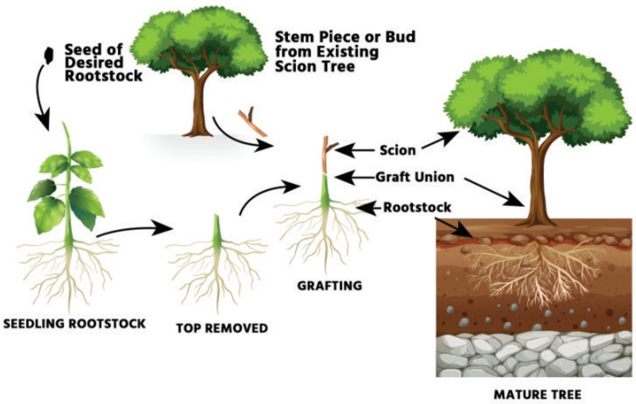

Fig. 9.9: Schematic process of grafting and budding

There are several methods for budding like shield budding, inverted T budding, patch budding, ring budding etc.

6. Micro-propagation: It is a rapid vegetative method of producing plants from specific plant parts like meristem tip, embryo, anther or auxiliary buds under aseptic (free from microbial contamination) condition. This method is also referred as tissue culture or *in vitro* culture. The plants are raised on artificially produced growth media with controlled temperature, humidity and light intensity. When grown under the same conditions, all of these plants are quite homogeneous. The tissue culture plants are true-to-type because they have the same genetic make-up from the source plant.

Advantages of Micro-propagation:

i. Through this technique, large number of plants can be multiplied within short span of time.

ii. The produced plants are free from any type of diseases.

iii. A whole plant can be developed from miniature plant parts like meristem, anther.

iv. The plants which can't be multiplied through seeds can be propagated through tissue culture techniques.

Disadvantages of Micropropagation

i. Proper skill and training are required for handling various activities involved in this method.

ii. The cost of setting up a tissue culture laboratory is very high.

iii. Minor contamination may damage the total plant sets.

9.6.2 Sexual Propagation

Multiplication of plants with the help of seeds is known as sexual propagation. Seeds are fundamental to reproduction process and formed as result of fusion of male with female gametes. A young plant raised from seed is known as seedling.

Advantages:

- Seedlings are easy to raise through this method and comparatively cheap.
- Sexually propagated plants generally live longer than vegetatively propagated plants.

Disadvantages:

- Sexually propagated plants have uneven growth, yielding capability, and fruit quality due to genetic segregation in heterozygous plants. Such seedlings frequently exhibit diversity and are not true to type.
- These types of plants take more time to reach maturity. For example sexually propagated mango seedlings require 8-10 years to reach maturity while a grafted mango plant matures within 3-4 years.
- Seedlings on their maturity attain greater size which makes the pruning, spraying and harvesting operations more challenging.

INTEXT QUESTIONS 9.6

1. Reproduction by means of vegetative parts is known as ....
2. Name one plant which develops tunicate bulb.
3. Most popular and easiest method of asexual reproduction is

   a. Cuttings　　b. Layering

   c. Micropropagation　　d. Grafting
4. What is micro-propagation?
5. Seedlings are raised from seeds (True/False).

ACTIVITY 9.1

Create your own garden using plant cuttings. Explain the steps you took in creating your own plant cuttings garden. What challenges did you face, and how did you overcome them? Reflect on the importance of proper care and environmental conditions in the success of plant propagation through cuttings.

....

....

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Notes

9.7 TYPES OF FRUITS

9.7.1 Fruits for Different Climates

Tropical climate	Subtropical climate	Temperate climate
Mango, Banana, Papaya, Guava, Sapota, Pineapple, Aonla.	Citrus, grapes, durian, jackfruits, litchi, pomegranate, date palm	Apple, Pear, Plum, Apricot, Peach, Strawberry, Kiwifruit, Apricot, Walnut.

9.7.2 Classification of Fruit Trees

1) Based on nature of growth

a. **Herbaceous**: They are characterized by their non-woody stems and flexible green structures. E.g. Banana, Pineapple

b. **Shrubaceous**: They typically have woody stems providing more structural support while still being softer than fully mature trees. They can be identified by their multiple stems and shorter height. E.g. Phalsa, Pomegranate

c. **Woody**: They are perennial plants characterized by their hard, woody stems. E.g. Mango, Sapota, Jamun, Guava

2) Based on continuation of growth

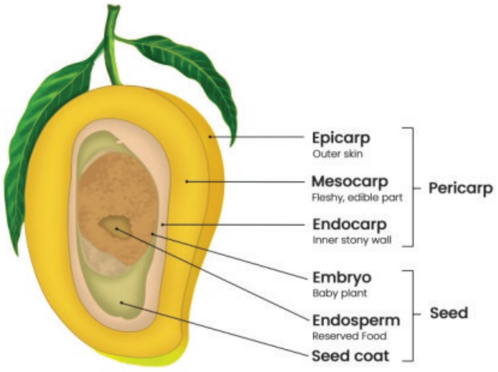
a. **Evergreen**: Evergreen fruit trees are perennial plants that retain their foliage throughout the year, providing a consistent source of fruit and greenery. E.g. Mango, Citrus, Litchi, Sapota

Notes

b. **Deciduous**: This type of fruit-bearing plants loses their leaves annually, typically during the autumn, as a strategy to conserve water and energy during unfavorable growing conditions. E.g. Apple, Pear, Peach, Plum, Apricot

9.7.3 Edible Parts of Different Fruits

1. **Mango:** Mesocarp
2. **Guava:** Thalamus, & Pericarp
3. **Banana:** Mesocarp & endocarp
4. **Citrus:** Juicy placental hair
5. **Pineapple:** Fleshy axis, bract, perianth and seeds



9.10 Structure of fruit

INTEXT QUESTIONS 9.7

1. Mango is considered as

    a. Tropical fruit   b. Subtropical fruit

    c. Temperate fruit   d. None of these

2. Give two examples of temperate fruits.
3. What is the edible part of citrus?
4. Banana is a ………….. type plant in nature of growth.

Notes

9.8 ORCHARD MANAGEMENT

An orchard is a type of farm where group of fruit bearing trees or shrubs are planted for the purpose of food production. It is commercial in nature. An orchard has generally only one type of plant and needs special care for maintenance which makes it different from forest. Considerable amount of time and labour is required to develop an orchard, hence careful planning is highly crucial for orchard management. Examples of some fruits commonly grown in orchard are apple, orange, banana and walnut.

9.8.1 Steps in Orchard Development

Following are the key steps which must be followed for successful development of an orchard:

1) **Selection of an Ideal Site:** An orchard is a long-term investment for a farmer. Therefore adequate attention should be given in selection of proper place for its establishment. Criteria for identifying proper location and site should be based on following criteria

   a. The climate of the location must be suitable for growing the desired plants.

   b. The soil fertility of the area must support the large-scale plantation. Generally deep (1 m), well-drained soil with neutral pH and gradual slope is ideal for orchard.

   c. The selected variety of the crop should be adaptable to local condition.

   d. Adequate water supply must be available throughout the year near the location.

   e. Proper transport facility must be available for bulk amount of transport by road or railways.

   f. Availability of market should be closer to orchard.

2) **Preliminary Operations:** After selection of suitable location, preliminary operations are performed to make the land suitable for orchard plantation. These operations are

   a. Any types of weeds, shrubs or trees are cleared from the site.

   b. Deep ploughing is essential to remove the big roots underneath the soil

   c. The land is leveled for uniform distribution of irrigation water.

d. If nutrient content of the soil is poor, green manure crops like sunhemp, dhaincha may be grown to improve fertility status of soil. For problematic soils like acid or alkali soil, a reclamation measures should be adopted with the help of lime or gypsum.

3) **Planning of An Orchard:** After the site selection and preliminary operations, next comes the establishment of an orchard with well designed plan. A careful planning of an orchard is highly important for efficient use resources to gain maximum profit. A good orchard plan may consider following aspects:

a. Choice of optimum amount of spacing between plants so that maximum no of plant can be accommodated in the orchard.

b. Water resources should be located at convenient places and irrigation channels may be developed along the land gradient.

c. Location and size of stores, office buildings should occupy appropriate location (preferably at centre) for efficient management.

d. Care should be taken so that farm roads and buildings should occupy minimum economic space.

e. If more than one type of plants is to be grown in single orchard, separate blocks may be developed for similar type of plants.

f. In order to protect orchard from stray animals or stealing of fruits, proper fencing around it is necessary. Mud walls, barbed wire fencing or live fencing may be developed for this purpose.

g. Rows of tall trees like *Casuarina equisetifolia*, *Eucalyptus globules* and *Azadirachta indica* may be planted around the orchard to protect it from high wind speed. These types of plants are called windbreak plant because they have ability to reduce the wind speed as well as excessive drying of soil and plant foliage.

4) **Layout of An Orchard**: Layout means how the plants are arranged in the orchard. An orchard layout should allow the maximum no plants possible in the given area and provide enough spaces to grow each tree. Broadly system of layout in orchard can be divided in two groups viz. a) vertical row planting system and b) alternate row planting system.

Notes

Vertical row planting system:

It is a type of planting system where trees grown in a particular row is exactly perpendicular to trees grown in another row. Further it is divided into

a. **Square system:** Here trees are planted at each corner of a square, therefore row to row and plant to plant distance remains same in this approach. This is most commonly followed and simplest of all lay out and planting. However relatively less number of plants is accommodated in this system.

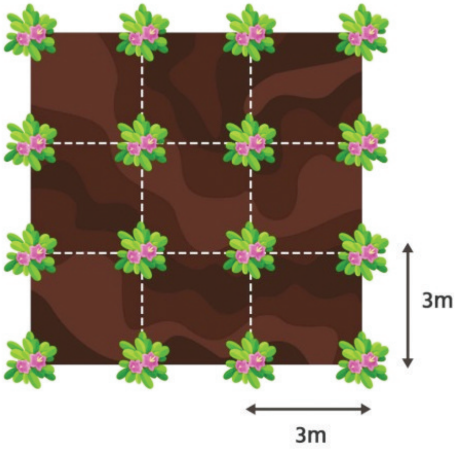


Fig. 9.11: Square system planting

b. **Rectangular system:** It is similar to square system, except that the distance between rows is more than distance between plants in the row. As size of the row is bigger than square system, intercultural operations like irrigation, training and pruning are easy to do in this system of planting.

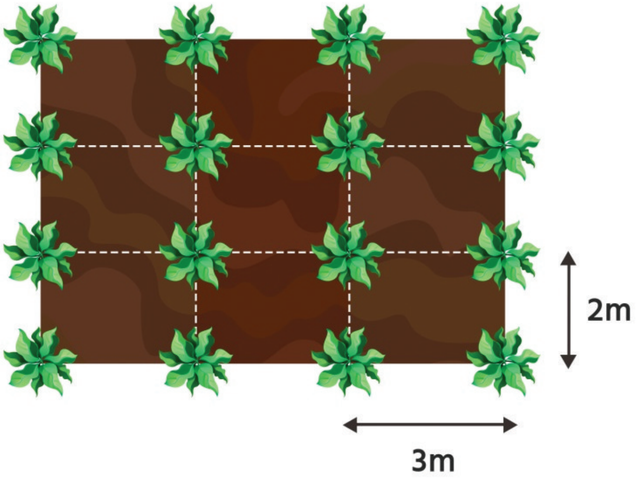


Fig. 9.12: Rectangular system planting

Alternate row planting system:

It is a type of planting system where trees grown in a particular row is not exactly perpendicular to trees grown in another row. Actually, trees in even row are exactly midway between trees in even row. Types of alternate row planting system are:

a. **Diagonal or quincunx system:** This is the modified form of a square system, where one more tree is planted at the centre of square. This layout has efficiently utilized the empty spaces of square system for economic benefit. Therefore, farmer can earn additional income from the filler crop. Examples of filler crops are banana, papaya, pomegranate etc.

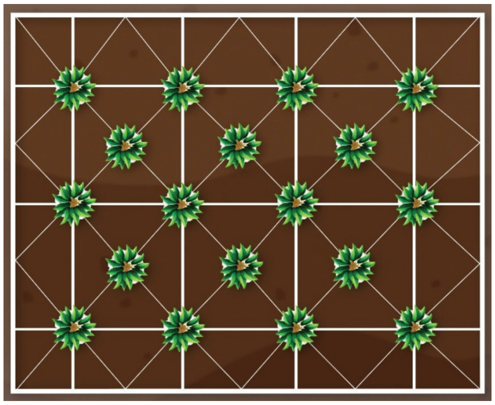


Fig. 9.13: Diagonal system

b. **Hexagonal system:** In this system the planting will be done in all corners of the equilateral triangle therefore this is also called as equilateral system. Ideally it is suitable for the fertile and well irrigated land. Compared to square system 15% more trees can be planted here. But skillful person is required to prepare the layout while intercultural operation becomes difficult as the planting is complicated.

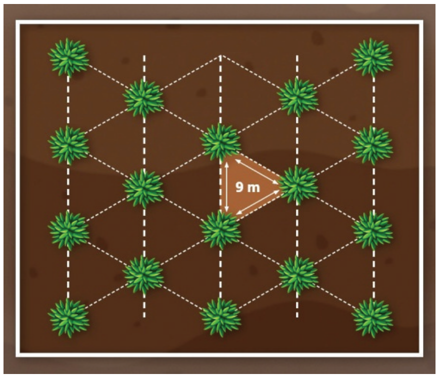


Fig. 9.14: Hexagonal system

Notes

c. **Contour system:** This system is particularly suitable for hilly areas where orchard management is difficult due to uneven topography and soil erosion. Here trees are planted along the contour (points of equal elevation) across the slope.

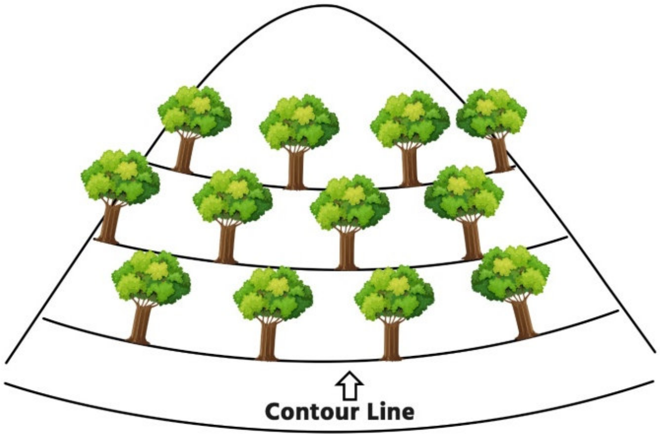


Fig. 9.15: Contour system of planting

d. **High density planting (HDP):** High density planting means planting of trees at a closer spacing than the recommended one using special techniques. The sole objective of this planting system is obtaining maximum productivity per unit area. The HDP is performed in apple and mango.

5) **Continuous monitoring and adaptation:** Regular monitoring of soil condition, plant health and performance of orchard is deciding factor to gain maximum economic benefit for farmers. Necessary care should be taken in timely manner if any problem in overall health of orchard is found.

INTEXT QUESTIONS 9.8

1. What is orchard?
2. Orchard is a short term investment (True/False).
3. Which is the simplest layout of an orchard?

   a. Rectangular system   b. Hexagonal system

   c. Square system   d. Quincunx system
4. Which type of planting system is followed in hilly region?

9.9 TRAINING AND PRUNING

In horticulture, training and pruning are important cultural practices which determine the yield and quality of fruit. An appropriately trained and pruned plant supports a large crop load and yields a plentiful high-quality produce. These two terms are often considered as same but technically both of them are done with different objectives and serve different purpose for plant.

9.9.1 Training

It is a process of judicious removal of selective part or parts of plant to give them proper shape and size so that plant can bear heavy load during fruiting season. Training starts from nursery stage of plants. An untrained plant is less productive due to excessive vegetative growth and weak in framework.

Objectives of training

- To make cultural operations easy in orchard plants
- To give the plants an attractive appearance
- To improve the penetration of sunlight and air at center of plant
- To increase production and quality of fruit

9.9.2 Pruning

It is a technique of removing plant parts like twigs, branches, leaves, flowers or roots to improve flowering and fruitfulness in plants. Pruning diverts the plant energy from vegetative parts to reproductive parts. Thus it helps to achieve better fruit quality and higher production.

Objectives of Pruning

- To make the plant more productive in terms of quality and yield
- To get more economic profit from orchard
- To increase the longevity of tree

Both the operations of training and pruning can be performed together to improve shape, size and yield of plants.

Notes

INTEXT QUESTIONS 9.9

1. Giving proper shape and size to the plant is main purpose of

    a. Training   b. Pruning

    c. Pollarding   d. Wrapping

2. What is pruning?

3. Training and pruning can be performed simultaneously (True/False).

9.10 FRUIT DROP AND BARRENNESS IN PLANTS – CAUSES AND REMEDIES

A fruit plant normally bears huge numbers of flowers but very small percentage of them actually develop in fruit which ultimately affect yield of the plant. For example, a single inflorescence of mange contains 5000 flowers but fruit setting only around five per inflorescence is sufficient to give good yield in the season. If a plant bears more fruits than its capacity at maturity, plants shed/drop fruits naturally in different times. But many a times excessive premature fruit drop happens in plants due to various reasons. Sometimes the plants are not capable of flowering and bearing fruit, this condition is referred as unfruitfulness or barrenness in fruit crops. This type of fruit drop and barrenness is matter of great concern to the farmers if not managed properly.

9.10.1 Causes and Remedies of Fruit Drop & Unfruitfulness

1. **Nutritional causes:** Lack of essential plant nutrients especially nitrogen and boron cause premature fruit drop. Heavy nitrogen fertilization during the initiation of floral buds delays blossoming by encouraging vegetative production. Therefore, nutritional requirement of plant should be maintained by adequate manuring and fertilization.

2. **Environmental causes:** Some fruit crops fail to produce sufficient yield in a region due to adverse environmental conditions like unfavourable temperature, rainfall and humidity. For example, north Indian varieties of mango have failed to bloom in south India. Ideally plants and their varieties should be selected as per climatic requirements.

3. **Pathological causes:** Infestation of crops with disease and pest causes fruit barrenness and reduces consumer demand in market. Such pests may be

managed by biological (with the help of natural prey and predators) or chemical (with the help of pesticide) ways.

4. **Cultural causes:** Most frequent cause of fruit drop in garden is excessive irrigation. Judicious amount of irrigation and proper drainage are advisable in this case. Weeds and intercrops compete with main plants for nutrients, water and sunlight and cause deficiency symptoms in plants. Therefore, weeding at right time and adequate manuring helps to protect main plants from barrenness.

5. **Mechanical causes:** Occurrence of cyclone, hail or wind storm during flowering and fruit bearing season causes excessive fruit drops.

6. **Lack of pollinators:** Pollination is the process of transferring pollen from the male part of a flower to the female part. Pollinators such as bees, butterfly, wasp, bat, beetles are the agents of pollination. Excessive use of pesticides kills such beneficial insects and causes inadequate fruit setting for production. Thus sensible use of pesticides is critical for sustainable food production.

9.10.2 Plant Growth Regulators as Remedial Measures

Another way of controlling such unfruitfulness and fruit drop is application of plant growth regulators (PGRs). PGRs are synthetic organic compounds which can regulate the plant physiological processes in favour of grower when applied in small concentration. They are similar like plant hormone but former is synthetic in nature and latter is synthesized by plant itself. Apart from fruit setting, PGRs are also useful for plant propagation, production of seedless fruit, induction of flowering, fruit ripening, breaking seed dormancy and tissue culture techniques. Based on type of action, PGRs can be divided into two types

1. **Growth promoter:** They help in growth and development of plant. E.g. auxins, gibberellins, and cytokinin

2. **Growth retardant:** They restrict natural growth of plants. It includes ethylene and abscisic acid (ABA).

Freshly harvested products should be managed carefully and scientifically to avoid any post-harvest loss of fruits and vegetables which may help us to attain food security for our fellow citizens.

Notes

INTEXT QUESTIONS 9.10

1. What is unfruitfulness?
2. Enlist any two reasons for severe fruit drop in plants.
3. Plant growth regulators are produced by the plant itself (True/False).

ACTIVITY 9.2

Imagine you are tasked with planning and designing a fruit orchard. Choose a specific fruit that you would like to focus on (e.g., apples, oranges, or mangoes) and outline the steps you would take to establish a successful orchard.

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WHAT YOU HAVE LEARNT

- Horticulture is a branch of agricultural science which primarily deals with cultivation of fruits, vegetables, plantation, spices & condiments, ornamental, medicinal and aromatic plants. Globally, India is the second largest producer of fruits and vegetables. Wide varieties of horticultural crops are cultivated in India due to presence of diverse climatic condition and soil types.
- Fruits and vegetables are called protective foods due to their richness of vitamin, mineral, fibre, carbohydrate, protein and fats. They fetch high price in market in comparison to food grain crops.
- Fruit crops are propagated through both sexual and asexual methods. But asexual methods like bulb, corm, rhizome, cutting, layering and grafting are more popular as true types of plants are developed in this reproduction technique.
- Fruits are classified into tropical, subtropical and temperate types according to their climatic requirement. Mango, banana, papaya are tropical fruits while grape, citrus, jackfruit are sub-tropical fruits. Cold season crops e.g. apple, strawberry, peach and plums are temperate fruits.

- An orchard is a type of farm where group of fruit bearing trees or shrubs are planted for the purpose of food production. An orchard is a long-term investment for a farmer therefore it needs careful planning and continuous monitoring for successful performance.
- Training and pruning are important cultural practices in horticulture for qualitative as well as quantitative improvement in fruits. Training is judicious removal of selective plant part or parts to give proper shape and size. Removal plant parts like twigs, branches, leaves, flowers or roots to improve flowering and fruitfulness is called pruning.
- Unfruitfulness and premature fruit drop are major problem in fruit production. Such problems are caused due to lack of nutrition, improper variety, unfavourable climate and pest attacks. This problem can only be remedied by proper identification of root cause and timely management.

TERMINAL QUESTIONS

1. What is the difference between agriculture and horticulture?
2. Enlist the major divisions of horticulture along with brief description.
3. Discuss the importance of horticulture.
4. How biotic and abiotic factors affect the fruit production?
5. Write different climatic zones for horticultural production in India.
6. Define asexual reproduction? Explain in brief about various types of asexual reproduction.
7. Why barrenness is common in fruit trees?
8. Analyze the advantages and disadvantages of sexual reproduction over asexual reproduction.
9. Why training and pruning are considered as important cultural practice in fruit horticulture?
10. Describe various systems of laying out in orchard.
11. What do you understand by micropropagation?

12. What is the usefulness of plant growth regulators in horticulture?

13. Classify the fruit crops according to their climatic requirement growth habit.

14. What are the key principles to be followed for successful handling of post-harvest products?

ANSWERS TO INTEXT QUESTIONS

9.1

1. Latin
2. False
3. Egypt (Option d)

9.2

1. Fruits and vegetables are rich source of vitamin, mineral, fibre, carbohydrate, protein and fats. Hence such crops are called protective foods.
2. True

9.3

1. Fruit (option b)
2. Olericulture
3. Tulsi and Kalmegh
4. Arboriculture

9.4

1. Six
2. Temperate (Option C)
3. North eastern subtropical

9.5

1. Abiotic factors
2. All of these (option d)
3. Response of plant to the changes in day length is termed as photoperiodism.

Notes

9.6

1. Asexual reproduction
2. Onion
3. Cuttings (option a)
4. Rapid vegetative method of producing plants from specific plant parts like meristem tip, embryo anther or auxiliary buds under aseptic (free from microbial contamination) condition is called micropropagation.
5. True

9.7

1. Tropical fruit (Option a)
2. Apple and strawberry
3. Juicy placental hair
4. Herbaceous

9.8

1. An orchard is a type of farm where group of fruit bearing trees or shrubs are planted for the purpose of food production.
2. False
3. Square system (option c)
4. Contour system

9.9

1. Training (Option a)
2. Pruning is removal of plant parts like twigs, branches, leaves, flowers or roots to improve flowering and fruitfulness in plants
3. True

9.10

1. When the plants are not capable of flowering and bearing fruit, this condition is referred as unfruitfulness.
2. Lack of nutrition and unfavourable climate
3. False

Notes

GLOSSARY

Shield budding: Here the bud piece acts like a shield. This method is also known as T-budding as the cuts given on the stock are of the shape of the letter T. E.g. Citrus, Rose etc.

Inverted T budding: In locations with frequent rainfall, the rainwater runs down from the stock's stem may enter the T-cut, soak through the bark, this type budding may prevent the bud piece from healing and sprouting.

Patch budding: A patch from a bark the same size that contains a bud from the desired mother plant is substituted. E.g., Rubber, Citrus, Cocoa, and Ber.

Ring budding: To prepare the bud, cut a 3 cm-wide circle of bark and place the bud inside. E.g., Cinchona.

Air layering (Gootee/Marcottage): Air layering is a propagation technique used to encourage root growth on a plant stem while it remains attached to the parent plant. This method is particularly effective for certain types of trees and shrubs that are difficult to propagate through cuttings. E.g., Crotons, Ficus

Ground layering: Ground layering involves bending a low-growing branch to the ground and burying a portion of it in soil while leaving the tip exposed. Roots develop from the buried section over time. E.g., Apple, Jasmine

Photoperiodism: It refers to response of plant to the changes in day length.

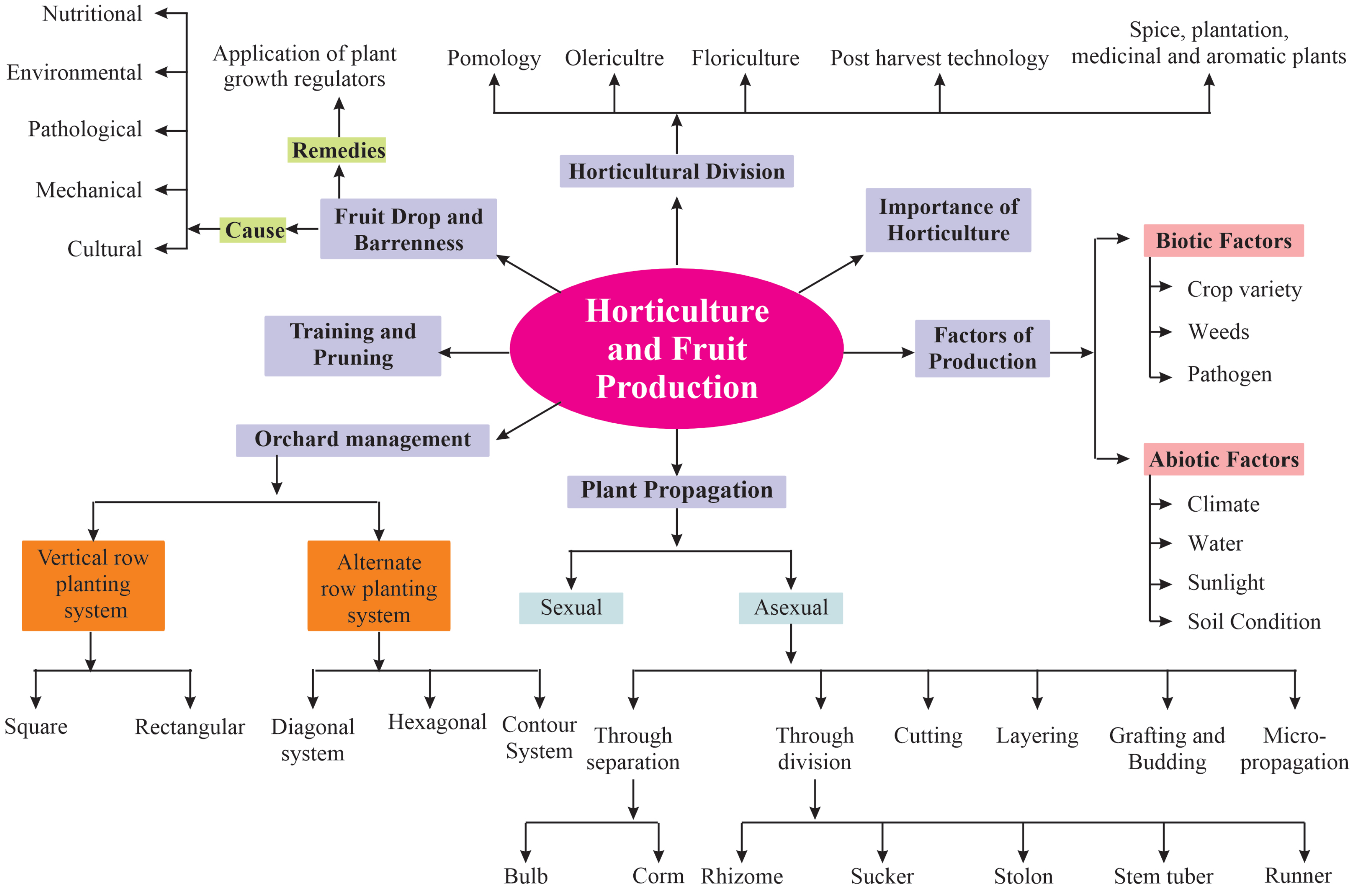
SUGGESTED READING

1. Chadha, K. L. (2019). *Handbook of Horticulture* (Vol. I & II), ICAR Publication, New Delhi.

2. Singh, J. (2014). *Basic Horticulture*, Kalyani Publishers, Ludhiana.

3. Kumar, N. (2021). *Introduction to Horticulture*, MedTech Science Press, India.

WHAT YOU HAVE LEARNT



NOTE

10

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VEGETABLE CROPS

'Eating colourful vegetables protects against various diseases and sharpens the eyes and mind'. As discussed in the previous lesson, vegetables are part of horticulture, and their scientific cultivation falls under olericulture. The term 'Olericulture' refers to a branch of horticulture that deals with the commercial cultivation, marketing, storage and value addition of vegetable crops. It is derived from the Latin words: '*Olus*' means cabbage and '*cultura*' means cultivation. Vegetables are short duration crops with high yield potential per unit area and time. India has diverse agro-climatic regions, ranging from sub-tropical to temperate, which are suitable for growing different kinds of vegetables throughout the year.

LEARNING OUTCOMES

After studying the lesson, the learner:

- differentiates between vegetable and fruit crops;
- summarizes the scope of vegetable cultivation in India;
- explains different types of vegetable gardens;
- describes the method to develop a vegetable nursery; and
- tabulates the cultivation techniques of common vegetables grown in India.

Notes

10.1 DIFFERENCE BETWEEN VEGETABLE AND FRUIT CROPS

Sr. No.	Vegetable crops	Fruit crops
1	Vegetables are mostly annual in nature	Fruits are mostly perennial in nature
2	Vegetables are generally herbaceous or have non-woody stem	Fruits generally have woody stem
3	Vegetables are eaten in raw, cooked or processed forms	Fruits are typically eaten in raw form
4	Vegetables are low in sugar	Fruits are high in sugar
5	Mostly vegetables are propagated by seeds	Mostly fruits are propagated by vegetative means i.e., cutting, grafting or budding
6	Vegetables are planted closely to each other *i.e.* within centimeters	Fruits are planted at wider distances *i.e.* meters apart
7	More labour is required for vegetable cultivation	Less labour is required for fruit cultivation
8	Vegetables are consumed at an immature and tender stage	Fruits are consumed at the ripe stage

INTEXT QUESTIONS 10.1

1. Olericulture is an important branch of ……………………

2. The branch of science that deals with the commercial cultivation, improvement and, value addition of vegetable crops is:

   a. Pomology   b. Olericulture

   c. Arboriculture   d. Floriculture

3. The word 'Olericulture' is derived from Greek language (True/False).

4. In nature, vegetables are mostly

   a. Annual b. Biennial

   c. Triennial d. Perennial

5. Vegetables have ……………..… or …………….. type of stem.

6. The sugar content in vegetables is ………… compared to fruits.

10.2 IMPORTANCE AND SCOPE OF VEGETABLE CULTIVATION IN INDIA

Indians mostly follow a vegetarian diet, and vegetable cultivation in India has tremendous scope for the following reasons:

- **Sources of nutrients**: Vegetables are also called 'protective foods' as they provide essential nutrients and antioxidants to our body that protect us from various diseases.

Sr. No.	Nutrients	Function	Vegetable Source	Deficiency disorder
1.	Carbohydrate	Provide energy	Potato, Sweet potato, Cassava, Yams	Growth retardation
2	Proteins	Formation of amino acid	Peas, cowpea and beans	Kwashiorkor disorder (Potbelly)
3	Calcium	Bone/teeth formation	Spinach, Coriander, Fenugreek, Amaranthus, Drumstick	Brittle bone and teeth
4	Iron	Essential component of hemoglobin	Drumstick leaves, mint, Spinach, Coriander, Fenugreek, Amaranthus	Anemia
5	Vitamin A	Overall health of body, eye health	Orange/yellow-colored vegetables viz., Carrot, Sweet Potato, Pumpkin, Tomato	Night blindness, dry skin

Notes

Sr. No.	Nutrients	Function	Vegetable Source	Deficiency disorder
6	Vitamin B complex	Important for nervous system, helps in heart functioning	Pea, Bean, Garlic, Tomato, Colocasia	Beriberi, Ulcer, sore tongue
7	Vitamin C	Essential for growth and disease resistance	Cabbage, cauliflower, Turnip, Tomato, Drumstick	Scurvy, loss of energy
8	Vitamin D	Health of bone and teeth	Leafy vegetables	Fragile bone and teeth
9	Vitamin E	Antisterility	Cabbage, Lettuce, Spinach	Affects fertility
10	Cellulose and Fiber	Helps in digestion	Okra, Leafy vegetables, Root crops	Constipation

- **Balanced diet**: Vegetables are key ingredient of a balanced diet. They provide dietary elements, minerals, protective nutrients and to some extent energy. According to the Indian Council of Medical Research (ICMR), New Delhi, an average adult should consume 300-350g/day of different type of vegetables (*i.e.* leafy, tuber and other vegetables) to obtain the necessary nutrients and minerals. Vegetables enhance the palatability of a diet through their attractive colour, taste, texture and flavour.

- **Prebiotic source**: Vegetables are also a source of prebiotics. Prebiotics are substances found in foods that feed probiotics (beneficial micro-organisms present in the gut). Tomato, onion, garlic, leek, etc. are the important sources of prebiotics.

- **Short duration:** Most vegetables are annuals, completing their crop cycle in one season, except for a few such as onion and carrot (biennial), and drumstick, ivy gourd (perennial). Examples of short duration vegetables include radish, green onion, spinach, fenugreek, and coriander, etc.

- **Higher yield**: Vegetable crops have higher yield (4-5 times) per unit area and time compared to most cereals, millets and oilseeds. For example, wheat yields 20-25q/ha, and paddy yields 25-30q/ha, while potato yields 150-200q/ha, and cauliflower yields 125-175q/ha. The yield of vegetables grown in polyhouses can exceed 500q/ha.

- **Suitable for diversification**: Due to their short duration, vegetables fit well into any cropping system and help to diversify the cropping systems. Diversification provides extra income, improves soil health and reduces the incidence of insect-pests and diseases.

- **Higher employment**: Compared to cereals and other crops, vegetable cultivation generates higher employment due to their short duration and increased frequency of intercultural and farm operations, which are mostly done manually.

- **High export potential**: Due to diverse agro-climatic conditions, high quality vegetables can be produced year-round in different parts of India. Vegetables are also ideal crops for protected cultivation, boosting their export potential. The pesticide residue free and quality vegetables are being exported to European, African and Middle Eastern countries.

Notes

INTEXT QUESTIONS 10.2

1. Carbohydrates provide ……………….. to the human body.
2. Which of the following vegetables is a source of proteins for our body?

   a. Pea   b. Potato

   c. Cabbage   d. Carrot
3. Deficiency of which element makes bone and teeth brittle?
4. Anemia can be prevented by adequate supplementation of the ……………element.
5. Which vitamin is also known as antisterility vitamin?
6. According to ICMR, New Delhi, the dietary consumption of vegetables for an adult should be:

   a. 50 g/day   b. 100 g/day

   c. 250 g/day   d. 350 g/day

Notes

7. Probiotics are harmful microorganisms present in the gut that help to decrease digestion (True/False).

10.3 CLASSIFICATION OF VEGETABLES

Over 10,000 plant species are consumed as vegetables worldwide, with around 50 being commercially cultivated. Therefore, it is important to classify vegetables for better understanding. Among the various methods of classification, botanical classification, classification based on life cycle, and culture are the most commonly followed.

Botanical classification: This is a universally accepted classification. All vegetables belong to Angiospermae division and are divided into two classes: Monocotyledoneae and Dicotyledoneae. Vegetables in the Monocotyledoneae class have fibrous root systems and parallel leaf venation, while those in the Dicotyledoneae class have tap root systems and net like leaf venation. The botanical classification of important vegetables is given in Table 10.1.

Table 10.1: Botanical classification of vegetables

Family	English name	Botanical name
	Monocotyledoneae	
Alliaceae	Onion Garlic	*Allium cepa* *Allium sativum*
Araceae	Arvi or taro	*Colocasia esculenta*
	Dicotyledoneae	
Chenopodiaceae	Spinach Beetroot	*Spinacia oleracea* *Beta vulgaris*
Convolvulaceae	Sweetpotato	*Ipomoea batatas*
Cruciferae	Cabbage Cauliflower Radish	*Brassica oleracea* var. *capitata* *Brassica oleracea* var. *botrytis* *Raphanus sativus*
Cucurbitaceae (Gourd Family)	Cucumber Muskmelon Watermelon	*Cucumis sativus* *Cucumis melo* *Citrullus lanatus*

Family	English name	Botanical name
Fabaceae/Leguminosae	Pea Cowpea Cluster bean	*Pisum sativum* *Vigna unguiculata* *Cyamopsis tetragonoloba*
Malvaceae	Okra or lady's finger	*Abelmoschus esculentus*
Solanaceae	Potato Eggplant or brinjal Tomato Chilli	*Solanum tuberosum* *Solanum melongena* *Solanum lycopersicum* *Capsicum annuum*
Apiaceae	Carrot	*Daucus carota*
Moringaceae	Drumstick	*Moringa oleifera*

Classification based on culture: In this system of classification, vegetables are grouped according to their requirements for cultural operations. Crops requiring similar cultural practices are placed in the same group. This method of classification is particularly important for farmers and students from cultivation and study point of view, respectively. Based on cultural practices, vegetable crops are grouped as follows:

- **Root vegetables**: These crops are cultivated primarily for their fleshy roots, which are found underground. These vegetables are mostly grown during the winter season and are planted on ridges, e.g., carrot, radish, turnip and beetroot, etc.

- **Cole crops**: These crops are mostly transplanted and cultivated during the winter season, e.g., cabbage, cauliflower, broccoli, and knolkhol, etc.

- **Leafy vegetables**: Crops in this group are typically directly sown at closer spacing for succulent leaves, e.g., spinach, fenugreek, coriander, etc.

- **Cucurbitaceous vegetables**: These crops are also known as gourd family crops. These are warm season vegetables and mostly grown in the summer season. They have vine type plant growth. This group includes crops that can be consumed as salads (cucumber, long melon), desserts (muskmelon, watermelon), cooked dishes (pumpkin, gourds), and for making petha (ash gourd).

- **Solanaceous crops**: These are mostly summer season transplanted crops and cultivated for their fruits, e.g. tomato, capsicum, chilli and brinjal.
- **Peas and beans**: These are pod vegetables that belong to the leguminosae family. Members of this group have tendrils as modified leaf structure, e.g. pea, cowpea, cluster bean and french bean, etc.
- **Bulb crops**: These crops have modified stem (bulb) that is consumed as vegetables, e.g. onion, garlic, etc.
- **Tuber crops**: These vegetables are cultivated for their fleshy underground tubers, e.g. potato, sweet potato, and cassava, etc.

Classification based on life cycle: Different vegetables require varying amounts of time to complete their life cycles. Therefore, vegetables can be grouped into three categories *viz*., annuals, biennials and perennials. Most vegetables are annuals in nature, i.e., they complete their life cycle in a single growing season or one year. Crops that require two consecutive growing seasons to complete their life cycle (producing seeds) are called biennial vegetables. Perennial vegetables are sown/planted just once and, after a certain period, continue to yield their economic parts (vegetables) year after year, e.g., drumstick (Moringa), asparagus, artichoke, Malabar spinach, colocasia. Perennial vegetables can be grown from three to 15 years depending on their economic yield.

INTEXT QUESTIONS 10.3

1. Vegetables belong to the .... division of the plant kingdom.
2. Vegetables in the Monocotyledoneae class have a .... type root structure and .... leaf venation.
3. Give two examples of vegetables from the Alliaceae family.
4. Cauliflower is a

   a. Root crop　　b. Cole crop

   c. Tuber crop　　d. Fibre crop
5. Potato, chilli, brinjal and tomato belong to the .... plant family
6. Which family of plant has a modified leaf structure called tendrils?

7. What is another name for cucurbitaceous family crops?

8. Based on life cycle, how many types of vegetables are classified ?

10.4 TYPES OF VEGETABLE GARDENS

On the basis of purpose and method of cultivation, the vegetable garden / cultivation can be grouped into the following six types:

1. **Home or kitchen garden**: This type of garden is located in and around the house to meet daily requirement of fresh vegetables for the family. The purpose of such gardens is to harvest pesticide free fresh vegetables. Soil based home gardens can vary in size and shape depending upon availability of space. They may be as small as 6m × 6m size (**Fig. 10.1**) or as large as 25m × 10m. In urban and peri-urban areas, kitchen gardening using agro-waste media such as cocopeat or compost is being practiced (**Fig. 10.2**). These models provide around 250-300 kg of vegetables year round, which is sufficient for a family's needs.

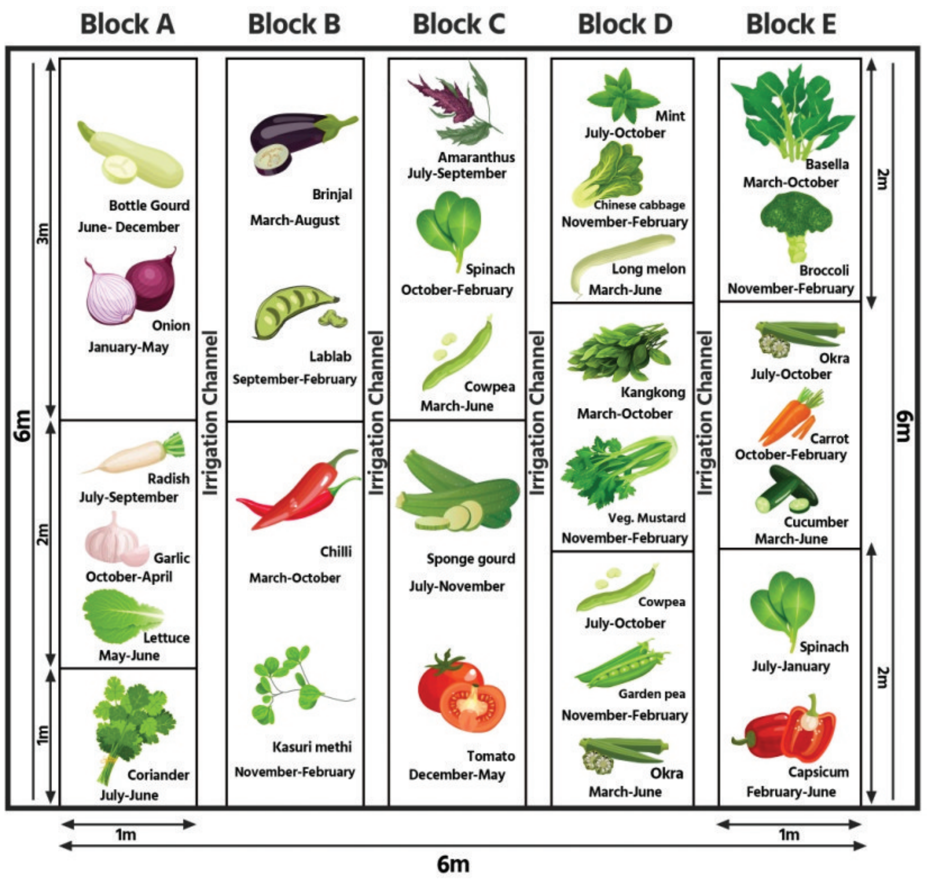


Fig. 10.1: Soil based vegetable nutrition garden model (6m × 6m)

Notes

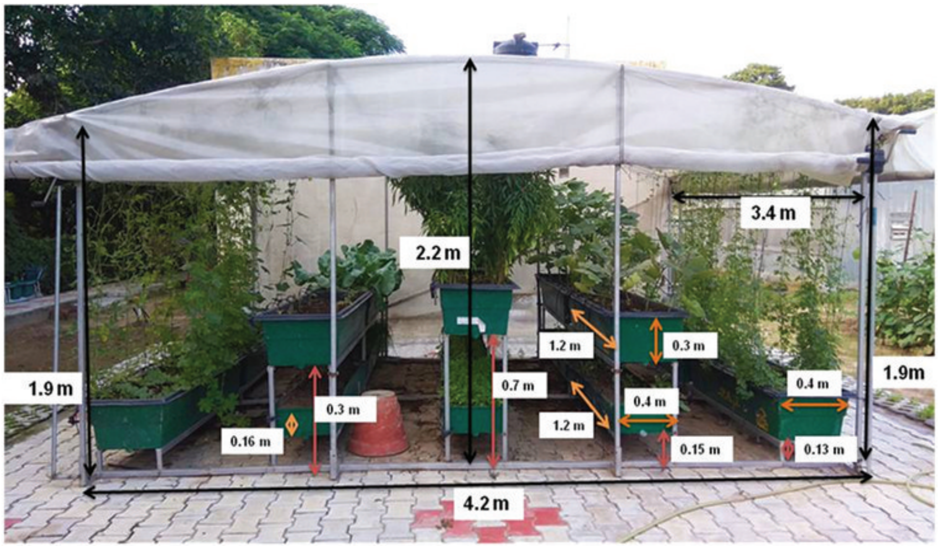


Fig. 10.2: Vegetable nutrition garden model using agro-waste (compost) plant growing media

2. **Market garden**: These gardens supply vegetables to the local market. They are mostly located within 15-30 km of cities, allowing farmers to quickly sell their produce due to proximity to the market and higher demand. Such gardens follow intensive cultivation practices and use higher inputs such as fertilizers and pesticides to maximize yield. Soil fertility is generally maintained through municipal compost.

3. **Truck garden**: This type of garden produces one or two specific crops in large quantities for distant markets. These gardens practice extensive cultivation over large areas using special techniques. The produce is sold in distant markets or cities, often hundreds of kilometres away, typically through middlemen.

4. **Vegetable garden for processing**: These gardens specifically produce vegetables for processing industries. Various vegetables are processed into products such as ketchup, sauces, puree, canned, frozen, or dehydrated products. In such gardens, specific varieties of crops are grown over large areas to ensure bulk supply, usually through contract farming.

5. **Vegetable forcing**: Forcing refers to growing vegetables outside of their normal growing seasons. In India, cucurbits are often cultivated on riverbeds before their usual cropping season. Protected structures such as polyhouses, net houses, and low tunnels are widely used to grow vegetables out of season.

6. **Organic vegetable garden**: Due to the adverse effects of chemical farming on soil, human and animal health, organic vegetable cultivation is gaining popularity among the consumers. The basic principle of organic farming is to feed soil but not the plant directly. In this type of garden, synthetic (inorganic) fertilizers and pesticides are replaced with natural sources such as farm yard manure, vermicompost, and plant based biopesticides.

INTEXT QUESTIONS 10.4

1. Depending on the purpose and method of cultivation, vegetable gardens are grouped into

   a. 2 b. 4

   c. 6 d. 8

2. Which type of garden is found around residential houses?

3. What is the purpose of market garden located near cities?

4. Extensive cultivation systems (use of low input) are followed in .... gardens.

5. Give one example of a vegetable used for vegetable forcing.

6. In which type of garden synthetic chemicals and fertilizers are replaced with natural resources?

7. The basic concept of organic farming is to feed .... but not .... directly.

10.5 NURSERY RAISING OF VEGETABLES

Nursery raising is a fundamental step in successful vegetable production. Its goal is to produce healthy and vigorous seedlings. A healthy nursery is the first and essential requirement to achieve the potential yield of a crop. It requires a smaller area; for example, a tomato nursery grown in 100m^2 area will be sufficient to transplant into one hectare area. A smaller area also facilitates the management of land, water and labour. Additionally, it allows enough time for field preparation after harvesting the preceding crop.

Notes

The vegetable nursery should be located in an area close to a water source and free from permanent shade. The land should not have water stagnation during rains and should be free from insect-pests (e.g., termites, nematodes) and diseases (e.g., damping off). The site should also be protected from stray animals. Different methods of nursery raising can be used, incuding soil-based, plug tray, and polybag-based nurseries. Differences among these nursery raising methods are given in Table 10.2.

Table 10.2: Differences amongst different nursery raising methods

Sr. No.	Soil nursery	Plug tray	Polybag
1.	Soil is used as growing media	Cocopeat: Perlite: Vermiculite (3:1:1) used as growing media	Soil + Farmyard Manure (FYM) (1:1) is used as growing media
2	Raised bed (15-20cm) are formed (**Fig. 10.3**)	Plastic plug tray is used (**Fig. 10.4**)	Polyethylene bags of 10 cm ×15 cm are used (**Fig. 10.5**)
3	Weed problem is there	No weed problem	Weed problem is there
4	Soil borne diseases may occur	No incidence of soil borne diseases	Soil borne diseases may occur
5	Soil sterilization with formaldehyde (1.5-2%) or soil solarization (hotter month i.e. April-June)	No need for sterilization	Soil sterilization can be done
6	Normal season nursery can be raised	Early nursery can be raised	Early nursery can be raised
7	Line sowing is followed	Single seed is placed in each cell	2-3 seeds are placed in each bag

Sr. No.	Soil nursery	Plug tray	Polybag
8	Competition between plants will be there	No competition between plants	No competition between plants
9	Thinning of weak and diseased plant is required	No need of thinning	Thinning can be done
10	Hardening treatment is required	No hardening is required	Hardening treatment is required
11	Roots may damage while uprooting plant	No roots will damage while uprooting plant	No roots will damage while uprooting plant
12	Examples include all vegetables, except cucurbits	Examples include all vegetables, especially F_1 hybrids	Examples include mostly cucurbits

Fig. 10.3: Raising of onion nursery by raised bed method with line sowing

Notes

Fig. 10.4: Raising of cucurbit nursery in plug tray method

Fig. 10.5: Raising of cucurbit nursery in polybag method

10.5.1 Protection of Nursery with Low Tunnels

Plastic low tunnels (low tunnel technology) are a miniature form of greenhouse that work on the principle of trapping long wave radiation and minimizing the exchange of temperature, humidity, and other environmental factors with the outside environment. These tunnels protect plants from low temperature, frost, rain, wind and other unfavourable conditions. Seeds sown in low tunnels or young plants covered with low tunnels can be protected from frost during winter. These tunnels are typically removed

during the month of February. For construction, 2m iron rods or bamboo sticks are bent into a semi-circle shape and fixed around the bed width, then covered with a polyethylene sheet (Fig. 10.6). This technology is primarily recommended for the early raising of vegetable nurseries or the early cultivation of crops.

Fig. 10.6: Plastic low tunnel for vegetable cultivation

Notes

INTEXT QUESTIONS 10.5

1. …………….. raising is the basic step in successful vegetable production.
2. The nursery area should be located in ………………. and near a ………… source.
3. Soil solarization can be done during

   a. April-June b. January - March

   c. July - September d. October – December
4. Soilless nursery growing media in the plug tray method is ……………: ……………..: …………………….
5. Which type of technology is used to protect young seedlings from rain, wind, low temperatures, frost, and other unfavourable weather conditions?

10.6 CULTIVATION OF VEGETABLES

In general, bold seeded vegetables such as okra, pea, and cowpea can be sown directly in the main field at recommended spacing during their growing seasons. However, seedlings of small seeded vegetables are raised in a nursery before being transplanted into the main field. Generally, 2-3 ploughings are required for land preparation. The recommended quantity of compost or farm yard manure (FYM) should be added at the time of the first ploughing. The crop-wise recommended doses of phosphorous and potassium fertilizers along with half the dose of nitrogen should be

Notes

applied just before final ploughing or ridge making. The remaining half dose of nitrogen should be applied either all at once or in two equal split doses to minimize leaching losses of nitrogen from the root zone. Direct sowing can be done throughout the day, but seedlings should be transplanted in the evening. A light irrigation should be applied immediately after transplanting to avoid transplanting shock and support the field establishment of the seedlings. After transplanting, timely irrigation, fertilizer application (remaining dose), training and pruning (in cucurbits, beans, and indeterminate tomato), earthing up (in potato, cauliflower, etc.), weeding, intercultural operations, insect-pest and disease management and harvesting activities should be performed efficiently for each crop. A summary of cultivation practices for important vegetables is given in Table 10.3.

Table 10.3: Summary of cultivation practices of important vegetable crops

Crop	**Variety/hybrid**	**Seed Rate (g/acre) and Sowing time**	**Spacing level**	**Approximate Yield (q/acre)**
Muskmelon	**Variety**: Arka Jeet, Pusa Madhuras, Punjab Sunehri, Hara Madhu**Hybrid**: Pusa Rasraj, MH-51, MH-27	400 gLast week of Jan-1st week of Feb	3m×60 cm	90.0
Watermelon	**Variety**: Sugar Baby, Durgapura Kesar**Hybrid:** Pusa Bedana (seedless), Arka Manik, Arka Jyoti	1.5-2 kgLate Jan-1st week of Feb	2.5-3m× 60 cm	70.0
Cucumber	**Variety**: Poinsett, Punjab Kheera-1, Punjab Naveen **Hybrid**: Pusa Sanyog	1.0 kgLate Jan-1st week of Feb	1.5-2m× 45-60cm	350

Crop	Variety/hybrid	Seed Rate (g/acre) and Sowing time	Spacing level	Approximate Yield (q/acre)
Tomato	**Variety**: Pant Bahar, Arka Saurabh, Roma, PVB-1, PVB-2, PVB-4, Punjab Ratta, Punjab Sona Cherry **Hybrid**: Pusa Ruby, Pusa Divya, Arka Vardan, TH-1 & PTH-2	100 gJuly, Sept and Oct	75cm× 30 cm	Open field: 250Protected Condition: 1000Cherry type: 400
Brinjal	**Variety**: Pusa Purple Long, Arka Shirish, Arka Kusumkar, Punjab Raunak, Punjab Bharpoor **Hybrid**: Pusa Kranti, Arka Navneet, PBH-3, PBH-4	300-400g June, Oct, Nov & Feb-March	67.5cm× 30-45cm	Variety: 150 Hybrid: 250
Chilli	**Variety**: Arka Lohit, Punjab Sindhuri, Punjab Tej, Bhagyalaxmi **Hybrid**: Pusa Jwala, Pant C-1, CH-52, CH-27	200g Oct-Mid Nov Feb-March	75cm× 45cm	Variety: 70 Hybrid: 100
Okra	**Variety**: Pusa Makhmali, Punjab Suhawani, Punjab 8, Punjab 7, Pusa Bhindi 5 **Hybrid**:	4-6 kg June-July	45cm× 15cm	50

Notes

Notes

Crop	Variety/hybrid	Seed Rate (g/acre) and Sowing time	Spacing level	Approximate Yield (q/acre)
	Pusa Sawani, Arka Abhay, Arka Anamika			
Onion	***Kharif*:** Arka Kalyan, Agri Found Dark Red, N-53 ***Rabi* :** Nasik Red, Arka Pragati, Pusa Ratnar, Punjab White, Punjab Naroya	4-5 kg***Kharif***: Sowing mid of June ***Rabi***: Nursery Oct-Mid Nov	15cm× 7.5cm	*Kharif*: 120 *Rabi*: 160
Pea	**Early**: AP-3, Arkel **Main**: Mithi Phali	Early: 45 kg Main: 30 kg	30cm× 7.5cm	Early: 30 Main: 60
Cole group	**Cauliflower**: Pusa Meghna, Pusa Sharad, Pusa Himjyoti,Pusa Snowball-1, Pusa Snowball Kt-25 **Cabbage**: Golden Acre, Pusa Ageti, Pusa Drumhead, Pusa Mukta **Broccoli**: Palam Samridhi, Pusa KTS-1	**Cauliflower**: 200-250g **Cabbage:** 200g **Broccoli**: 250g	45cm× 45cm	Cauliflower: 90-120 Cabbage: 80-100 Broccoli: 60-70
Potato	**Early Season**: Kufri Ashoka, Kufri Surya **Mid Season**: Kufri Jyoti, Kufri Lalima **Late Season**: Kufri Badshah, Kufri	13-18 q/acre	60cm× 20cm	Early: 100 Mid: 150 Late: 125 Processing:165

Crop	Variety/hybrid	Seed Rate (g/acre) and Sowing time	Spacing level	Approximate Yield (q/acre)
	Megha **Processing**: Kufri Frysona, Kufri Chipsona-1			
Root Crop	**Radish:** Arka Nishant, Pusa Chetki, Pusa Himani **Carrot:**Pusa Rudhira, Pusa Kesar, Pusa Yamdagini **Beet root:** Crimson Globe, Early Wonder	Radish: 4 kg Carrot: 4 kg Beet Root: 3 kg	45cm× 7.5cm	Radish: 140-150 Carrot: 180-200 Beet root: 250-300

INTEXT QUESTIONS 10.6

1. …………………….. seeded vegetables are sown directly in the main field.
2. When FYM or compost is incorporated into the soil?
3. Why nitrogenous fertilizer is applied in split doses to field?
4. Intercultural operation specifically followed in potato and cauliflower crops is:

   a. Training b. Pruning

   c. Retting d. Earthing up

5. Which is the seedless variety of watermelon?

   a. Sugar Baby b. Pusa Bedana

   c. Arka Manik d. Durgapura Kesara

6. Cucurbits are mostly sown during …………………… months.

Notes

WHAT YOU HAVE LEARNT

- Olericulture, derived from Latin words, is a branch of horticulture that deals with the commercial cultivation, improvement and value addition of vegetable crops.
- Vegetables are closely planted annual, biennial or perennial crops with non-woody stem (sometimes woody, as in certain perennial vegetable plants, e.g. Moringa). They can be eaten raw or cooked and are low in sugar.
- Vegetables are the good source of nutrients and pre-biotic and thus help in providing a balanced diet. These short duration crops have higher yields and their cultivation generates employment opportunities. Vegetables also help diversify cropping systems and have high export potential.
- Vegetables are classified on the basis of botanical families (mostly acceptable), cultural practices and life cycle.
- Based on purpose and cultivation, vegetable gardens can be of several types: home (for family), market (nearby city), truck (distant market), processing (industry), forcing (off season cultivation), and organic (no chemical use) gardens.
- Nursery raising is a basic step of vegetable cultivation where small seeded crops are sown, and special care must be taken. After attaining proper age, seedlings are transplanted into the main field.
- Of the three methods of nursery raising i.e. soil, plug tray, and polybag based nurseries, the plug tray method is most commonly used as it provides seedlings with enough space and nutrients for growth.
- Low tunnel technology is a mini greenhouse that protects plant from adverse climatic conditions.
- Land preparation, nursery raising, fertilizer application and various intercultural operations are crucial for producing high quality vegetables and achieving higher prices.

TERMINAL QUESTIONS

1. Define Olericulture. Write down the difference between vegetables and fruits.
2. What are the importance and scope of vegetable cultivation in India?
3. Why are vegetables called protective food? Describe with suitable examples.
4. Describe different ways of classification of vegetables with suitable examples.
5. What are the different types of vegetable gardens? Explain briefly.
6. What is nursery raising? Describe steps involved in nursery raising.
7. Briefly describe the advanced method of nursery raising.
8. What are low tunnel technology and its principle? How to construct it?
9. Describe the cultivation practice of Muskmelon, Tomato, Chilli and Potato under the following heads:
    - i. Variety/hybrid
    - ii. Spacing
    - iii. Seed rate and Sowing time
    - iv. Fertilizer
    - v. Yield
10. Describe the cultivation practice of Onion, Pea, Watermelon and Cauliflower under the following heads:
    - i. Variety/hybrid
    - ii. Spacing
    - iii. Seed rate and Sowing time
    - iv. Fertilizer
    - v. Yield

Notes

Notes

ACTIVITY

1. Visit nearest vegetable garden and fruit orchard and record visual differences on the basis of leaf, stem, fruits, spacing between plants, etc.
2. Collect pictures of different vegetables as classified on the basis of culture, i.e. root crops, cole crops, leafy vegetables, cucurbitaceous crops, solanaceous crops, bulb crops and tuber crops.
3. Plan a soil based vegetable nutrition garden model around your house (as given in Fig. 10.1) according to suitable growing season.

ANSWERS TO INTEXT QUESTIONS

10.1

1. Horticulture
2. Olericulture (Option b)
3. False
4. Annual (Option a)
5. Herbaceous, non woody
6. Low

10.2

1. Energy
2. Pea (Option a)
3. Calcium
4. Iron
5. Vitamin E
6. 350 g/day (Option d)
7. False

10.3

1. Angiospermae

2. Fibrous root, parallel leaf venation
3. Onion and Garlic
4. Cole crop (Option b)
5. Solanaceae
6. Leguminosae
7. Gourd crop
8. Three types

10.4

1. Six
2. Home/kitchen garden
3. To supply vegetables in local market
4. Truck garden
5. Cucurbits
6. Organic garden
7. Soil, plant

10.5

1. Nursery
2. Shade free, water source
3. April-June (Option a)
4. Cocopeat: Perlite: Vermiculite
5. Low tunnel technology

10.6

1. Bold seeded
2. At last ploughing during land preparation
3. To avoid leaching loss of nutrients
4. Earthing up (option d)
5. Pusa Bedana (option b)
6. January-February

Notes

GLOSSARY

Earthing-up: It is an intercultural operation in which soil is picked up and placed near the stem of a plant to cover its roots.

Hardening: This refers to the process of stopping irrigation to avoid transplanting shock and reduce mortality of young seedlings.

Hi-tech nursery: This involves the production of nursery plants in enclosed structures such as polyhouses or net houses, providing suitable environmental conditions for the growth of young seedlings.

Intercultural operation: These are cultural operations performed from sowing or transplanting to harvesting, especially when the crop is in the main field.

Olericulture: Olericulture is a branch of horticulture that deals with the commercial cultivation, improvement, and value addition of vegetable products.

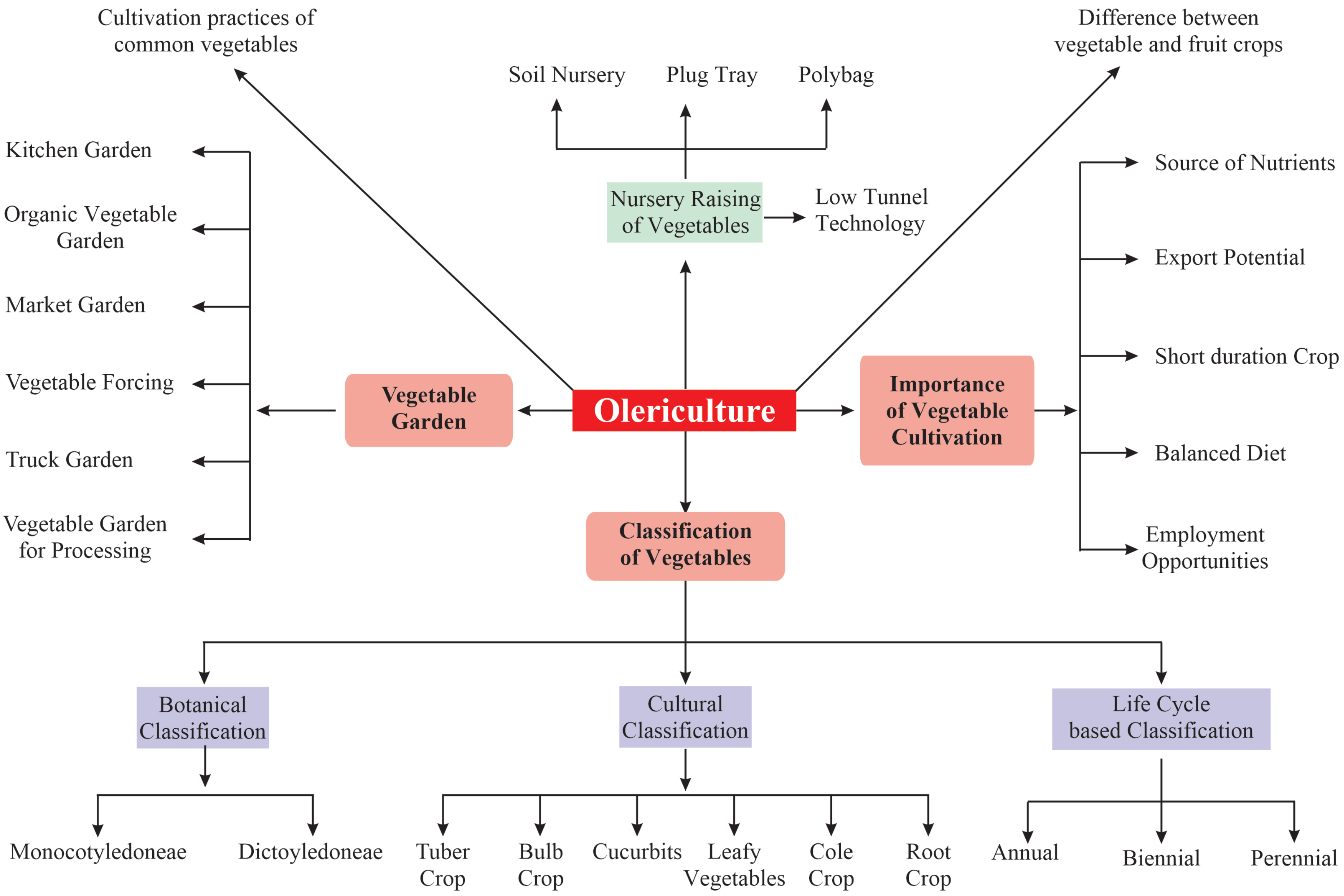
Prebiotics: Prebiotics are substances that increase beneficial micro-organisms in the human gut.

Vegetable forcing: This involves growing vegetables outside their normal growing season using various structures, such as greenhouses or low tunnels.

SUGGESTED READINGS

1. Choudhary, B. (2003). *Vegetables*, National Book Trust, New Delhi.
2. Chadha, K. L. (2019). *Handbook of Horticulture* (Vol. I & II), ICAR Publication, New Delhi.
3. Thamburaj, S. and Singh, N. (2014). *Textbook of Vegetable Tuber Crops and Spices*, ICAR Publication, New Delhi.

WHAT YOU HAVE LEARNT



NOTE

11

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FLOWER CROPS

Floriculture is an important branch of horticultural science. It deals with commercial cultivation of cut flowers, loose flowers, ornamental seasonal flowers, ornamental foliage plants, trees, shrubs, climbers, palms, cacti, succulents and bulbous flower crops along with their value-added products. Landscape gardening is also an essential component of floriculture industry which deals with planning and designing of residential and public gardens with diverse plant materials. We know that production of seasonal flowers and their seeds are established businesses in India. Floriculture has tremendous potential in both domestic and international markets due to their aesthetic value, essential oils, fragrance and perfume industry. Cultivation of flowers is one of the best options for improving farmers' income. It also provides gainful employment opportunities for youth through nursery raising, marketing, making ready to use items for consumers, exports and flower-based industries.

LEARNING OUTCOMES

After studying this lesson, the learner:

- defines floriculture and its prospects in India;
- describes the popular flower species cultivated in India;
- recommends suitable shrubs and climbers for specific purposes; and
- discusses the different components of commercial floriculture.

11.1 IMPORTANCE OF FLORICULTURE

Floriculture is important from aesthetic, social and economic point of view. It has the potential for generating employment opportunities year-round and earning foreign

exchange. Different flower based value-added products such as flower bouquets, garlands, potpourris, perfumes, essential oils, and edible flowers etc. are the main export items. The commercial floriculture comprises field cultivation of cut flowers and loose flowers. It also covers mass multiplication of ornamental plants in nurseries for sale and beautification of the landscape.

Notes

The floriculture crops have huge export potential in countries such as United States, Germany, the United Kingdom, the Netherlands and the United Arab Emirates (UAE). The Agricultural and Processed Food Products Export Development Authority (APEDA) is responsible for the export, promotion and development of floriculture in India. To boost the export of floriculture products, the Government of India has set up six agri-export zones for floriculture in Maharashtra, Sikkim, Tamil Nadu (two zones), Uttarakhand and Karnataka. As per the National Horticultural Database, the major flower producing States are Tamil Nadu, Karnataka, Andhra Pradesh, West Bengal Maharashtra, Madhya Pradesh, Gujarat and Haryana etc. Seasonal flowers and seed production is an established business in Punjab, Karnataka and Maharashtra. The United States, Germany, the United Kingdom, the Netherlands and the United Arab Emirates (UAE) are the major countries, which import floricultural produce to India.

11.2 PROSPECTS OF FLORICULTURE IN INDIA

Since time immemorial, India has a tradition of growing flowers. In our country, it is considered as a high growth industry. Export-oriented flower production has increased due to the government's favourable policies. The scope of floriculture in India lies in:

- The opportunities for floriculture are increasing due to diverse uses of flowers in aesthetic sense, urbanization and substantially increased purchasing power of people.
- The demand for floricultural plants and their produce such as bouquet, garland, flower veni and value-added products like dry flowers and potpourris are increasing by the day. They are required in various functions and celebrations.
- Our country is well located between major flower markets, i.e., Europe and East Asia.
- The diverse agro-climatic conditions in the country enable the growers to produce all type of flowers in one season or the other.
- Landscaping has become an integral component of urban horticulture, which add aesthetic value to a place, reduces air and noise pollution, and improve local environment.

- Lawn grass production, lawn establishment and maintenance have emerged as lucrative enterprises and become an integral part of landscaping.
- In light of climate change and health benefits, the scope of turf or lawn grasses, vertical gardening, roof gardening, etc. is on rise.
- Production and marketing of potted plants also opened avenues for plant rentals for interior decoration in hotels, corporate houses, etc.
- The nursery industry is coming up as a flourishing enterprise, giving high returns. There is a huge demand for high quality flower seeds including hybrids.
- Protected cultivation of cut flowers has a great future in our country due to high returns.
- Extraction of essential oils, natural dyes, and pharmaceutical and nutraceutical compounds from flower plants is also a lucrative business.

INTEXT QUESTIONS 11.1

1. Floriculture is an important branch of ....
2. Number of agri-export zone set up by Govt. of India to promote floriculture

   a. 10   b. 6

   c. 4   d. 8
3. APEDA stands for ____________________
4. Give three examples of value-added products made from flowers.
5. What is extracted from flowers for use in pharmaceutical industry?

11.3 CUT FLOWERS

These flowers are harvested with stalk or cut stems, especially for arrangement in vases and bouquet displays. These cut stems last long if harvested at proper stage of maturity and immediately kept in cold condition to avoid post-harvest losses. Rose, Gerbera, Tuberose, Gladiolus and Chrysanthemum are very popular and widely cultivated cut flowers in India. States, such as Karnataka, Maharashtra, Andhra Pradesh, Orissa, Uttar Pradesh and Gujarat are the leading cut flower producing states. Cut flowers are used in the preparation of floral bouquets, floral baskets,

Notes

corsages, flower arrangements and for decoration of ceremonial vehicles. The botanical name, family origin, cultivation and utility of popular cut flowers have been tabulated in the following Table no. 11.1.

Table 11.1: Popular cut flowers commercially cultivated in India

Sr. No	**Common name**	**Botanical name**	**Cultivation**	**Utility**
1.	Rose	*Rosa hybrida*	Open/ Protected	Cut flower, pot plant, petals for garnishing sweets, shrub or bush, climber, hedge, source of essential oil, potpourris.
2.	Chrysanthemum	*Dendranthema grandiflora*	Open/ Protected	Cut flower, loose flower, garland making, floral bouquets, corsage (unopened flower bud attached over pocket of coat), pot culture, bedding
3.	Gladiolus	*Gladiolus grandiflorus*	Open	Bouquet, bedding plant, pot plant
4.	Lily	*Lilium species*	Protected	Cut flower, bouquet pot plant
5.	Gerbera	*Gerbera jamesonii*	Open/ Protected	Cut flower, floral bouquet, flower arrangement, bedding plant
6.	Carnation	*Dianthus caryophyllus*	Protected	Cut flower, bouquet, pot plant, garland, flower arrangement
7.	Cymbidium orchid	*Cymbidium* spp.	Protected	Cut flower, flower arrangement, garland, hanging basket, potted plant

Sr. No	Common name	Botanical name	Cultivation	Utility
8.	Tulip	*Tulipa hybrida*	Open/ Protected	Cut flower, borders and bedding plant, pot plant, floral bouquets

INTEXT QUESTIONS 11.2

1. Which of the following is the leading state in producing cut flowers?

   a. Rajasthan   b. Karnataka

   c. Jammu & Kashmir   d. Assam

2. Name two popular cut flower species of India.

3. The botanical name of Rose is ....

4. .... is a species of orchid.

5. Unopened flower bud attached over pocket of coat is called ....

11.4 LOOSE FLOWERS

These flowers are plucked from the plants when the flowers are fully matured and are harvested as loose without stem. These are plucked with hands by giving a gentle twist just below the calyx. Loose flowers are in great demand for making veni, rangoli, bracelets, hair adornments for women and garlands, for garden displays, religious offerings and decorative purposes. Loose flowers include many traditional flowers like Marigold, China Aster, Jasmine, Crossandra, Barleria, etc.

Table 11.2: Popular loose flowers commercially cultivated in India

Sr. No.	Common name	Botanical name	Utility
1.	Marigold	*Tagetes species*	Garland, home decoration, poultry industry, oil industry, pigment extraction

Notes

2.	Jasmine	*Jasminum species*	Oil industry, Gajra (flower garland worn by women during festive occasions), veni, garland preparation
3.	Desi Rose	*Rosa spp.*	Potpourri, Gulkand, oil extraction, incense stick, garland, flower arrangements
4.	Chrysanthemum	*Dendranthema grandiflora*	Garland, flower arrangements, oil extraction
5.	Tuberose	*Polianthus tuberosa*	Gajra, veni, oil extraction and garland
6.	China aster	*Callistaphu schinensis*	Loose flower
7.	Lotus (National flower of India)	*Nelumbo nucifera*	Garland, flower arrangements, dry flower

INTEXT QUESTIONS 11.3

1. The loose flowers are harvested as

   a. Without sepal　　b. Without petal

   c. Without calyx　　d. Without stem

2. Loose flowers are used for making .... & ....

3. Give two examples of commercially cultivated loose flower crops.

4. Gulkand is made from

   a. Marigold　　b. Rose

   c. Lotus　　d. Jasmine

5. Which flower is known as national flower of India?

Fig. 11.1: Loose flower and cut flower of chrysanthemum

11.5 SHRUB & SHRUBBERY BORDER

A shrub or bush is a small to medium-sized perennial woody foliage and/or flowering plant producing single or multiple stems from the base with profuse branches and leaves forming a low crown. These shrub plants are used for making beautiful live borders in gardens or roadsides. A wide border made in a garden where shrubs are thickly planted according to their height, foliage and flower colour for mass display to enhance the beauty of a garden is called a shrubbery border.

Classification based on landscape use

1. **Beautiful flowers:** *Hibiscus rosa-sinensis, Bougainvillea* spp., *Ervatamia spp.* etc.

2. **Oil Extraction:** *Jasminum* spp., *Plumeria* spp., *Pandanus tectorius* and *Rosa* spp.

3. **Loose flower:** *Jasminum.*, *Crossandra* spp. and *Rosa bourboniana* etc.

INTEXT QUESTIONS 11.4

1. A small to medium sized perennial woody foliage or flowering plant producing multiple stems from base is known as ....

2. The shrub which is used for oil extraction

   a. *Hibiscus rosa-sinensis*   b. *Rosa* spp.

   c. *Jasminum* spp.   d. Both b & c

Notes

3. What is shrubbery border?

11.6 CLIMBER PLANTS

Climbers are important component of landscape gardening. Climbers are defined as the group of plants possessing weak stem and have the ability to climb up the support with the help of modified organs to receive sunlight and air. Nature has equipped these climbers with different modified organs such as tendrils, thorns, hooks, root exudates, claws etc.

Classification of climbers

- **Sunny situation:** *Pyrostegia venusta, Quisqualis indica, Antigonon leptopus, Adenocalymma alliaceum, Bougainvillea spp., Campsis grandiflora* etc.
- **Partial shade:** *Clerodendrum splendens, Petrea volubilis, Lonicera japonica, Trachelospermum jasminoides* etc.
- **Climbers for pots:** Certain plants can be planted in pots and made to train over a support like climbers e.g. *Bougainvillea spp., Clitoria ternatea, Clerodendrum thomsoniae* etc.
- **Indoor decoration:** Shade loving climbers like *Scindapsus aureus, Monstera deliciosa, Philodendron* spp., *Asparagus* spp. etc. can be grown in pots and kept for indoor decoration.
- **Screening purpose:** Climbers with hanging growth habit form an effective screen.These are planted on ground and tied at the top of a building with sufficient space for the branches to hang down. e.g.*Vernonia elaeagnifolia, Pyrostegia venusta* etc.
- **Annual climbers:** Certain climbers are seasonal in nature and can be grown in pots or placed alongside the fence by directly sowing their seeds e.g. Sweet peas, trailing nasturtium. There are semi-woody climbers, which can also be grown as annual climbers like *Ipomea purpurea, Clitoria ternatea* etc.

INTEXT QUESTIONS 11.5

1. The modified organs of climbers are

   a. Tendril   b. Hooks   c. Claws   d. All of these

2. The climbers have strong woody stem (True/False).

3. Sweet pea and trailing nasturtium are the examples of ....type climber.

4. Which type of climbers is preferred for indoor decoration?

11.7 CUT GREENS (FRESH LEAVES AND STEMS)

Cut greens are used as fillers in bouquets along with cut flowers in flower arrangements and elsewhere for increasing aesthetic value. These floral produces have various other uses in making attractive fresh floral designs and floral arrangements, such as bouquets, wreaths, decoration of house interiors etc. Some of the cut foliage in demand are Asparagus, Ferns, Thuja, Cupressus, Eucalyptus etc.

Fig. 11.2: Cut greens in flower bouquets.

11.8 POTTED PLANTS

The potted plants are used with the purpose to decor homes, offices, commercial complexes, corporate offices, hotels, malls and other sites for various functions and events. These can be easily carried to places for immediate beautification and decoration of landscape of places. Some examples of potted plants are Aglaonema, Aralia, Azalea, Begonia, Calathea, Chlorophytum, Croton, Diffenbachia, Dracaena, ferns, Ficus, Kalanchoe, Maranta, Money plant etc.

Notes

11.9 FLOWER SEED PRODUCTION AND BULBOUS ORNAMENTALS

There is a high demand for quality flower seeds, especially annuals and ornamental plants. The varied agro-climatic conditions of India have enabled the cultivation of seed production of practically all type of flowers of winter, summer and rainy season. Seasonal flowers and seed production is an established business in Punjab, Karnataka and Maharashtra. Planting materials of bulbous ornamentals such as Gladiolus, Tuberose, Amaryllis, Dahlia, Lilies, Freesia, Tulip, Calla Lily etc., are also cultivated, multiplied and marketed in India.

11.10 ANNUALS

The annuals are classified based on season of growing and height at full maturity. These can also be classified for different purpose for beautification of a landscape depending upon their growth and flowering characteristics as mentioned below:

Classification of Annuals Based on Season:

Season	Time (Months)			Examples
	Sowing	Transplanting	Flowering	
Summer annuals	Last week of February	End March-April	May-July	Kochia, Portulaca, Zinnia, Sunflower, Gaillardia, Gomphrena, etc.
Rainy annuals	First week of June	First week of July	August -October	Balsam, Cock's comb, Amaranthus, Tithonia, etc.
Winter annuals	First week of October	Last week of October to November	December-March	Aster, Sweet William, Petunia, Clarkia, California poppy, Nemasia, Gazania, Salvia, Statice, Candytuft, Calendula, Phlox etc.

Classification of Annuals Based on Landscape Use:

1. **Bedding:** Calendula, Phlox, Verbena, Dahlia, Petunia, Nemasia, Sweet Sultan, Antirrhinum, Acroclinum, Aster, Marigold, Balsam, Zinnia, Sunflower, Gaillardia, Gomphrena etc.

2. **Pot growing:** Aster, Petunia, Gazania, Cineraria, Salvia, Nemasia, Brachycome, Pansy, Mesembryanthemum etc.

3. **Fragrant flowers**: Sweet William, Sweet Sultan, Sweet Pea, Sweet Alyssum, Mignonette etc.

4. **Shady situation:** Salvia, Cineraria and Nasturtium.

5. **Dry decoration:** Nigella, Briza, Bells of Ireland, Statice, Helichrysum, Acroclinum, Brumus, Lagurus, Gomphrena.

Fig. 11.3: Various annual flowers for landscape use

INTEXT QUESTIONS 11.6

1. Which are used as fillers in bouquets along with cut flowers?
2. Which types of plants are gaining popularity for ornamental purpose due to decreasing open spaces?
3. Potted plants are easily carried to different places for decoration (True/False).
4. Give any two examples of bulbous ornamentals.
5. Sowing time of rainy season annuals is ....
6. What is the flowering time of summer annuals?

Notes

11.11 NURSERY

Ornamental nurseries are meant for multiplication and sale of planting materials, besides providing guidance and landscape consultancy in planning, execution and maintenance of gardens. Ornamental plant nursery is a lucrative retail or wholesale business for the supply of various type of saleable plants such as annual flower seedlings or rooted saplings of trees, shrubs, climbers, foliage plants, bulbous plants, cacti and succulents, palms, indoor plants, grasses, bulbs, etc.

11.12 LAWN

Lawn is a well-mown turf maintained either in the sports field, in residential garden, or in a public park. Lawn is an integral part of the garden, providing a lush green open space and a beautiful environment. It is a green carpet for landscape also referred to as ‘heart of garden’. Lawn has aesthetic and recreational value too. It also provides a suitable background for flower beds, shrubbery border and specimen tree. It improves the monetary value of a property. Different types of grasses are used in the landscape designing and establishment of lawns in sports fields like cricket, golf, hockey, tennis, etc.

Fig. 11.4: A rose garden lawn

11.13 ARBORICULTURE

It is the practice of establishing and managing growth and development of woody perennials such as ornamental trees, generally for the purpose of attractiveness.

Classification of ornamental trees based on adaptability:

a) **Drought prone sandstone rocky sites:** *Albizia lebbek, Butea monosperma, Tecomella undulate, Casurina equisetifolia, Melia azedarach.*

b) **Saline areas:** *Acacia* spp., *Azadirachta indica, Prosopis* spp, *Chorisia* spp., *Phoenix dactylifera, Phyllanthus emblica.*

c) **For normal sites:** *Ficus benjamina, Ficus lacor, Polyalthia longifolia, Bauhinia* spp.

11.14 PERFUMES

The demand for natural floral extracts like perfumes from flowers is increasing by the day. Some flowers, such as Rose, Jasmine, Screwpine (kewra) and Tuberose are used for the extraction of essential oils for the preparation of perfumes or attar.

Notes

11.15 COLOURING PIGMENTS

Flowers are used to extract natural pigments. Carotenoids extracted from flowers are used commercially in the pharmaceutical industry, and as food supplements, animal feed additives and food colourants. Marigold petals (processed for lutein extraction) are used as an important feed additive for poultry birds to add to the yellow colour of egg yolk. A yellow coloured dye extracted from chrysanthemum is also used in food products and cosmetics. Orange-red edible dye is extracted from the arils (soft coating of seeds) of *Bixa orellana* (sinduri) is used in cosmetics and medicines for coating.

11.16 DRIED FLOWERS

The dry flowers can be easily dried, preserved and processed to retain their beauty and everlasting character. To dry the flowers and foliage there are different techniques used. The most common technique is air drying. The flowers such as Dahlia, Larkspur, Paper Flower, Annual Chrysanthemum, Marigold, Straw Flower, Lotus Pods are highly valued as dry flowers etc.

11.17 BONSAI

Bonsai is a technique of growing trees and shrubs in miniature form by dwarfing often up to a height of 15-20 cm. It is a Japanese art having origin in China. Some most commonly used trees and shrubs for bonsai preparation include Ficus species such as Banyan, Chilkan and Pilkan. Hardy and drought tolerant shrubs such as Bougainvillea, Adenium, Tecoma can also be planted for bonsai establishment etc. Preparation of Bonsai requires proper knowledge and skill for training, watering and nutrient management to maintain the plant in miniature forms.

Fig. 11.5: Bonsai

Notes

11.18 TERRARIUM

A terrarium represents a garden in an enclosed glass container. Terrarium culture is a delightful way to grow a collection of small plants well adapted to grow in an enclosed glass jars. With proper care ensuring adequate bright light, a terrarium will create a humid atmosphere that will enable growth of certain plants which normally don't survive under low humidity conditions. A terrarium culture also builds up a favourable environment for plant propagation. Suitable plants for terrarium are variety of succulents (*Echeveria, Crassula, Kalanchoe, Sedums* etc.)

Fig. 11.6: Terrarium

INTEXT QUESTIONS 11.7

1. Places where multiplication and sale of planting materials are done is known as

   a. Lawn　　　b. Green house

   c. Nursery　　　d. Terrarium

2. What is called as 'heart of garden'?

3. The science of establishing and managing growth and development of woody perennials is known as ……………………...

4. Name any two plants from where perfume/attar is prepared.

   a. ………………..

   b. ………………..

5. Lutein is extracted from the petals of ....

6. Why flowers are dried?

7. The technique of growing miniature form of trees are termed as ....

8. What is terrarium?

Notes

WHAT YOU HAVE LEARNT

- Floriculture is an important branch of horticulture, which deals with commercial cultivation of cut, loose flowers, ornamental, seasonal plants, perennials (trees, shrubs, climbers and palms), foliage plants, cacti, succulents, dried flowers, bulb production along with their value-added products.
- Landscape gardening is also an essential component of floriculture industry with aesthetic and functional value. It deals with the planning and designing of residential and public gardens with diverse plant material.
- Strategically and geographically, our country is well located between major flower markets, i.e., Europe and East Asia.
- The diverse agro-climatic conditions in the country enable the growth of all type of flowers in one season or the other.
- Flowers like Rose, Gerbera, Tuberose, Gladiolus and Chrysanthemum are very popular cut flowers and widely cultivated in India.
- Traditional flowers like Marigold, China Aster, Jasmine, Crossandra, Barleria are used as loose flowers for making Veni, Rangoli, Bracelets, Hair adornments and garlands.
- Aglaonema, Aralia, Azalea, Begonia, Calathea, Chlorophytum, Croton, Diffenbachia and Dracaena are important indoor potted plants for beautification.
- Asparagus, Ferns, Thuja, Cupressus, Eucalyptus are used as cut foliage or cut green plants for making bouquets and floral decorations.

TERMINAL QUESTIONS

1. Describe the following with suitable examples.

   I. Floriculture

   II. Cut flowers

   III. Cut greens

   IV. Landscape gardening

2. Describe the prospects of floriculture in India.

3. Describe the importance of lawn in a public park.

4. What is indoor gardening? Give suitable examples.

5. Give two examples of the following ornamentals:

   I. Shrubs

   II. Annuals

   III. Trees

   IV. Climbers

   V. Indoor plants

6. Describe the term ‘Bonsai’ with suitable examples of tree species.

7. What is arboriculture? Briefly explain the landscape use of ornamental trees.

8. What are the climber plants? Give suitable examples.

9. Describe classification of annual flowers with suitable examples.

10. Enlist the value added products made from flower crops.

11. What is Terrarium? Write importance of it in beatification of interior design.

Notes

ACTIVITY

1. List the requirements and prepare a plan for developing a lawn in open space in your vicinity.
2. Write the different activities involved in growing of annual flowering plants.
3. What are the employment generating activities you find in floriculture.
4. Collect all the requirements and prepare a beautiful bouquet for presenting to the chief guest visiting to your area.

ANSWERS TO INTEXT QUESTIONS

11.1

1. Horticulture
2. 6 (option b)
3. Agricultural and Processed Food Products Export Development Authority (APEDA)
4. Flower bouquets/garlands/potpourris
5. Essential oils

11.2

1. Karnataka (option b)
2. Rose, Gerbera
3. Rosa hybrida
4. Cymbidium
5. Corsage

11.3

1. Without stem (option d)
2. Rangoli and garland

3. Marigold and Jasmine
4. Rose (option b)
5. Lotus

11.4

1. Shrub
2. Both b & c (option d)
3. A wide border made in a garden where shrubs are thickly planted to enhance the beauty of a garden is called a shrubbery border.

11.5

1. All of these (option d)
2. False
3. Annual climbers
4. Shade loving

11.6

1. Cut greens/fresh leaves and stems
2. Potted plants
3. True
4. Gladiolus and Tuberose
5. 1st week of June
6. May – July

11.7

1. Nursery (option c)
2. Lawn
3. Arboriculture
4. Rose and Jasmine

Notes

5. Marigold
6. To retain their beauty and everlasting character
7. Bonsai
8. Terrarium is a garden in an enclosed glass container.

GLOSSARY

Arboriculture: Science of cultivation of woody plants and their management in diverse landscapes.

Cut flower: Flowers that are harvested at appropriate stage of maturity with cut stems attached to their base.

Dry flowers: Flowers that are dried physically (partial shade) or chemically (using desiccants) for decoration of interiors.

Floriculture: Floriculture is an important branch of horticulture, which deals with commercial cultivation of cut flowers, loose flowers, ornamental seasonal flowers, ornamental foliage plants, trees, shrubs, climbers, palms, cacti, succulents and bulbous flower crops along with their value-added products.

Landscaping: Landscape gardening is also an essential component of floriculture industry with aesthetic and functional value. It deals with the planning and designing of residential and public gardens with diverse plant material.

Loose flower: Flowers that are harvested when these are fully mature and they do not possess cut stems underneath their base.

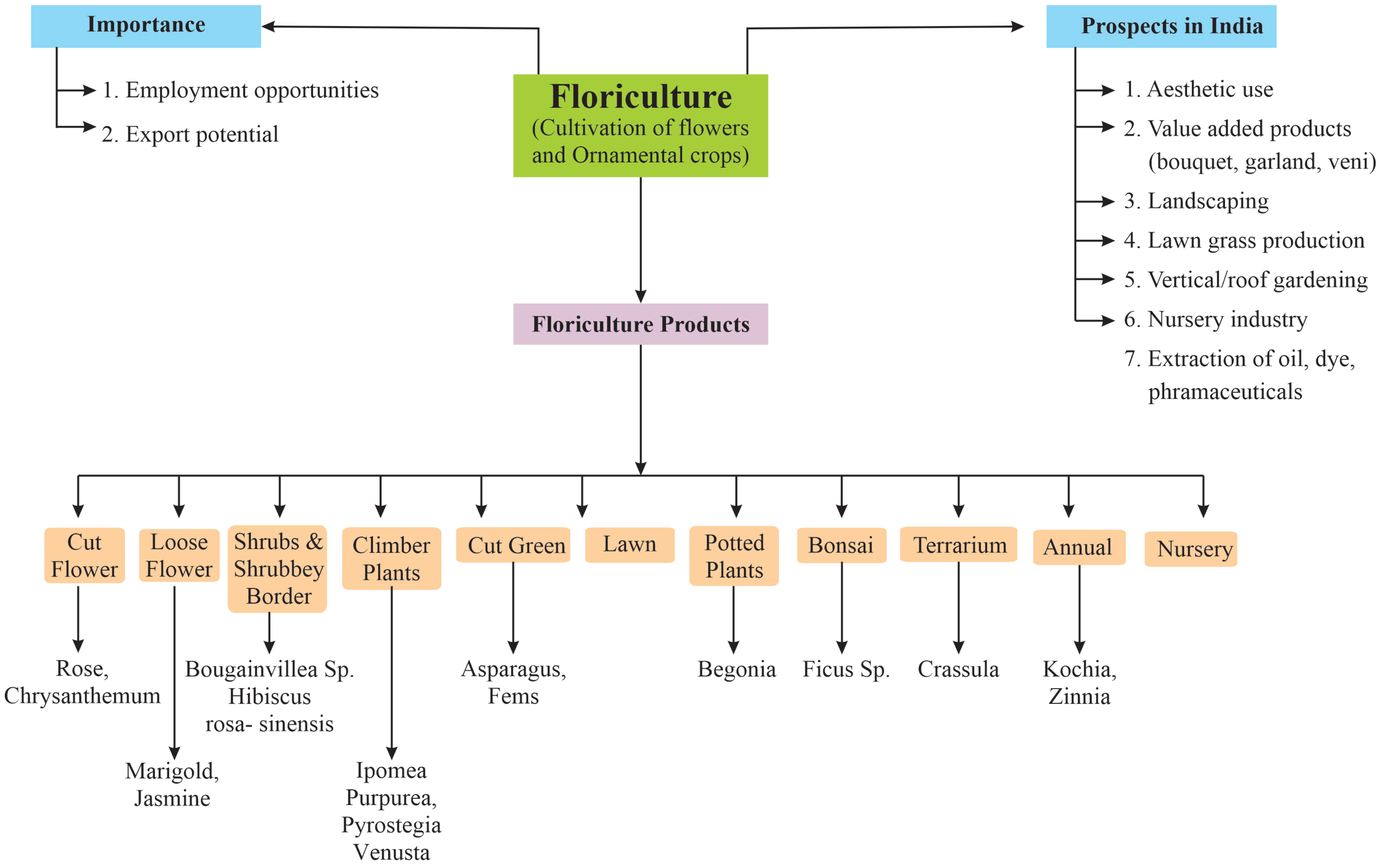
Value addition: Process of adding a value to raw produce to make attractive and useful products.

SUGGESTED READINGS

1. Arora, J. S. (2016). *Introductory Ornamental Horticulture*, Kalyani Publishers, Ludhina.

2. Randhawa, G. S. and Mukhopadhyay, A. (1998). *Floriculture in India*, Allied Publishers, New Delhi,

WHAT YOU HAVE LEARNT



MODULE -3

Post-harvest Management

12. Need and Importance of Post harvest Management

13. Processes in Postharvest Management System

14. Storage and Warehousing

12

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NEED AND IMPORTANCE OF POST HARVEST MANAGEMENT

You may have seen in newspaper the frequent incidences of price rises of common vegetables like potato, tomato or onion. Have you ever thought about why such significant price increases occur during particular periods of the year? One of the probable reasons for this is poor post harvest management of agricultural produce. Although, increasing agricultural production is considered the primary way to meet the growing demand for food, preventing losses after harvesting agricultural produce is another important option to achieve the goal of 'food for all'. India is major producer of paddy, maize, wheat, sorghum, pearl millet (bajra), fruits and vegetables in the world. However, a significant share of agricultural production in India is wasted due to post harvest losses. These losses are especially prominent in the case of perishable and bulky food commodities such as fruits and vegetables. These post harvest losses affect the availability of foods to consumers and increase their prices. Thus, post harvest loss remains an alarming issue in developing countries like India, where notable improvements have yet to be made.

LEARNING OUTCOMES

After studying this chapter, the learner:

- explains the importance of post harvest management;
- identifies the reasons for post harvest loss;
- classifies the different types of post harvest loss; and
- indicates the advanced technologies to manage post harvest loss.

Notes

12.1 CAUSES AND EFFECTS OF POST HARVEST LOSS

Agricultural and horticultural crops are the main sources of income for farmers. They also provide livelihood for their sustenance. However, the value of crops may degrade after harvest if they are not handled properly. Horticultural crops (fruits, vegetables and flowers) are more perishable in nature than cereals or pulses and are prone to post harvest losses. Such food loss can be caused by variety of factors, including unfavourable weather conditions, improper crop production practices, inappropriate management during harvesting, handling, and processing, a lack of efficient transportation facilities, and poor storage infrastructure. Climate change is also amplifying these losses through erratic weather, which disrupts post harvest activities. The causes of post harvest losses can be divided into different categories:

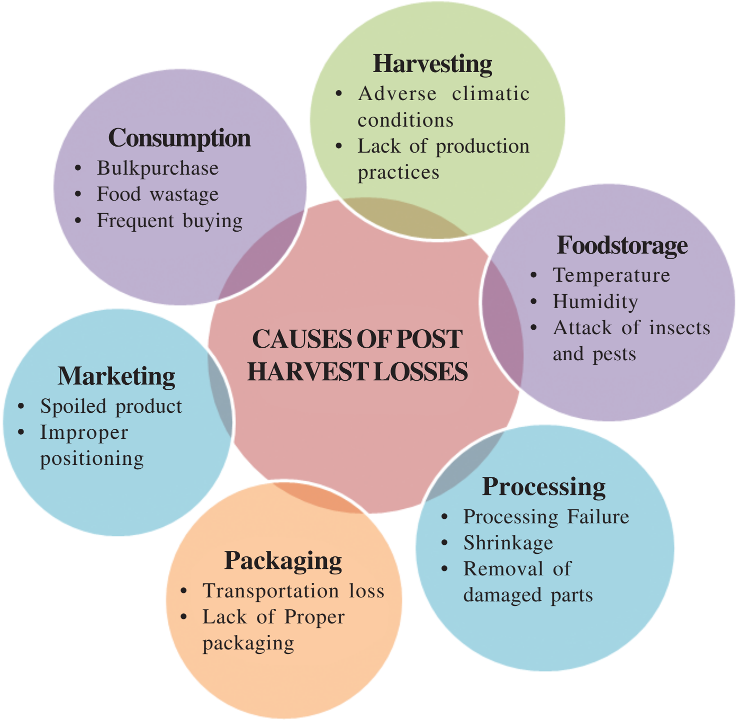


Fig. 12.1 Causes of post harvest losses

A. Mechanical Losses

Horticultural crops are highly prone to mechanical injury due to their soft, tender texture and high moisture content. Poor handling, inappropriate containers, improper packaging, and transportation can easily cause injuries such as bruising, breaking, and cutting.

B. Metabolic Losses

The respiration process continues in all freshly harvested commodities, which result in the reduction of food reserves and cause ageing through the production of ethylene. Transpiration also continues in such commodities, leading to a loss of moisture content and a decline in quality of the produce.

C. Developmental/growth Stages

Germination of seeds before or after harvesting of crops, sprouting during storage of tubers or bulbs crops, and root development in stored commodities such as onion and carrot all cause a loss in nutritional content and quality.

D. Pathological and Insect-pest Deterioration

Microorganisms like fungi, bacteria, yeast, and other organisms attack crops after harvest, leading to high post-harvest losses. Most of the fresh commodities have an abundance of moisture and nutrients but they lack strong defense mechanisms, allowing microbes to spread rapidly in them.

E. Physiological Deterioration

Agricultural crops such as cereals, pulses, oilseeds, fruits and vegetables continue their physiological activity even after harvest. Mineral deficiencies, damage caused by extreme temperatures, and low or high humidity contribute to physiological deterioration. Enzymatic activity also leads to over-ripeness and senescence during this period.

F. Lack of Technical Support

Farmer needs technical support for quality planting materials, pest management, weather information, market insights, and storage facilities to scientifically manage their produce. The unavailability of such support often results in a significant compromise in the quality of agricultural produce.

G. Low market Demand

Over production of agricultural crops during certain parts of the harvest season saturates the consumer demand for the food products in market and create a situation leading to a market glut. In such situations, farmers are forced to sell their produce at low prices or risk it deteriorating on the farm or in the market areas.

Notes

H. Poor Storage Facility

Excess crop produce could be stored for future use, however, sufficient storage facilities are often unavailable. Due to the perishable nature of these foods, any surplus is prone to rotting over time because of poor storage conditions.

I. Improper Utilization

The losses may also result from inadequate preservation, food preparation, and cooking techniques.

12.1.1 Effect of Post harvest Losses (PHL)

Post harvest losses of crop produce have lasting impacts on a country's economy and population.

- Improper harvesting techniques and rough handling of agricultural crops cause damage and injuries to fruit and vegetables, making them inedible.
- Damage to harvested products lowers their quality and market value, affecting both consumers' health and farmers' income.
- It reduces the opportunity for export to international markets.
- These losses create food shortages and disrupt supplies, especially for vulnerable communities.
- A significant amount of water, energy, and labour is required to produce crops; post harvest losses represent a waste of these resources.
- Decay and decomposition of wasted food or crop emit greenhouse gases which contribute to global warming.
- Post-harvest losses (PHL) represent a loss in both the quantity and nutritional quality of food, affecting acceptance in international markets and leading to economic losses for nations.

INTEXT QUESTIONS 12.1

1. PHL stands for ....

Notes

2. Horticultural crops (fruits & vegetables) are more prone to mechanical injury due to

   a. Low water content

   b. Hard texture

   c. High nutrient content

   d. Tender texture

3. Name any four reasons responsible for post harvest loss of food products.

12.2 WHY POST HARVEST MANAGEMENT?

The main aim of post harvest management is to ensure that agricultural crop comes with least amount of loss with maximum effectiveness from harvest to consumption resulting in better economic returns for growers, processors, and consumers. India produced 315.7 million tons of food grains during the year 2021-22, while horticultural production during the same period was 320.48 million tons. Still, 30-40% of the total crop is spoiled due to improper post harvest treatment. Reducing post-harvest losses is crucial for attaining global food security. When such losses are reduced and food quality is maintained, farmers, traders and handlers will be able to increase their income, thereby minimizing numerous social and economic problems. Therefore, effective management of post-harvest systems can greatly help in:

- **Loss prevention:** Both quantitative and qualitative losses of agricultural produce can be prevented.
- **Value addition:** Value addition to raw materials helps to gain more profit.
- **Digestibility:** Processing makes food materials more edible and digestible.
- **Maximization of nutritional value:** Proper storage retains nutrients for longer periods. It also improves synergy among minerals and reduces antagonistic effects of nutrients in food.
- **Organoleptic properties**: Effective management optimizes the appearance, colour taste, and texture of foods to meet consumer preferences.
- **Food safety:** Prior sanitation of food products can prevent food spoilage and reduce the chances of microbial contamination. For example, application of UV ray prevents bacterial contamination in eggs.

INTEXT QUESTIONS 12.2

1. Inadequate post harvest management results in both ………………. and ……………. types of loss.
2. Give two examples of organoleptic food properties.

Notes

12.3 TYPES OF POST-HARVEST LOSS (PHL)

Post-harvest losses begin during grading, packaging, storage, transportation, distribution, wholesale market, and retail marketplaces. Estimating these losses is essential for planning strategies to increase the availability of food for the population. Post harvest losses include weight loss, peeling, bruises, over-ripening, blanching losses, and spoilage, caused by microorganisms, insects, pests and rodents. Processing losses, on the other hand, include peeling, coring, trimming, pitting, blanching, and heat processing. Types of losses can be classified as:

1. Quantitative Loss:

The decrease in the weight of agricultural produce is termed as quantitative loss. The reason for this type of loss may be spilling, attack of insects, pests, and rodents.

2. Qualitative Loss:

It is caused due to mechanical damage or microbial contamination of the crops.

3. Nutritional Loss:

This refers to the reduction in the nutrient content of food as a result of quantitative or qualitative loss.

4. Germination Loss:

Germination loss refers to a decrease in the viability of seeds, which is particularly important for sprouts and microgreens.

5. Financial Loss:

It refers to the reduction in the economic value of product due to a reduction in either quantity or quality.

12.3.1 Important sites of Post-harvest Losses:

In India, significant post harvest losses are observed at the following stages:

- Farmer's field (15 - 20%)
- Packaging (15 - 20%)
- Transportation (30 - 40%) and
- Marketing (30 - 40%)

12.4 ADVANCED TECHNOLOGIES TO MINIMIZE LOSSES

Post-harvest technology refers to all treatments or procedures applied from the time of harvest to consumption of products. Preventing post harvest losses is generally less costly than producing an equivalent amount of agricultural crops, especially fruits and vegetables. Various technologies are available to extend the shelf life of agricultural produce:

A. Waxing

Waxing forms a protective layer on fruits and vegetables, reducing moisture loss and respiration rates while extending storage life.

B. Evaporative Cool Storage

This is an ideal method for short-term storage of crops at the farm level, particularly for perishable crops. It also reduces shrivelling and increases the storage life.

C. Pre-packaging

This technology regulates the rate of respiration and transpiration, keeping the products fresh at both room temperature and low temperature. Because of its low cost and availability, it can bring benefits for both the consumers and producers.

D. Cold Storage

Cold storage extends the storage period by lowering the rate of respiration and delaying ageing.

Notes

E. Modified Atmosphere Packaging (MAP)

This technology modifies the atmospheric inside packaging to extend shelf life. For instance,

- MAP can increase the shelf life of green chillies, cavendish bananas, and sweet peppers (capsicum) by 8, 15, and 13 days, respectively.
- Storing papayas in a low density polyethylene (LDPE) bag at 10-12 °C under modified atmosphere (MA) conditions can extend storage time by 4 weeks.

F. Controlled Atmosphere (CA) Storage

The principle behind it is to create and keep a storage room with controlled environment which has higher concentration of CO_2 and lower concentration of O_2. This slows down the rate of respiration and delaying ageing. It is more efficient when used in combination with low temperature storage.

G. Cold Chain

A cold chain involves performing a sequence of operations in a controlled low temperature environment to transport fresh agricultural commodities from farm to consumer. It aids in minimizing wastage and maintaining the quality of crops.

H. Irradiation

When ionizing radiation (such as gamma rays) is applied to fruits and vegetables at the right dosage level, it can delay ripening, reduce insect damage, and prevent microbiological contamination and sprouting and rotting in tuber and bulbous crops like garlic, onion, and potatoes during storage. It also works as disinfectant and kills pests like papaya fruit fly, mango seed weevil, and citrus fruit fly.

I. Edible Coatings

Edible coatings made from lipids, proteins, and polysaccharides serve as food wraps and turn into food ingredients when consumed with food. Their advantages are as follows:

- An edible coating enhances structural integrity, improves mechanical handling, maintains the quality and reduces microbial damage.
- It controls immigration of gases and moisture exchange, and retains volatile flavour compounds.

J. Others

Other services for perishables crops (like fruit and vegetables) at the farm level include harvesting, washing, cleaning, grading, packaging and value addition.

- Value addition must ensure higher returns for producers and farmers while delivering better product quality to consumers.
- Appropriate packing materials should be used for both the export of fresh produce and modified atmosphere packaging.
- It will be beneficial to create novel food alternatives like fibre, single-cell proteins, and enzymes from byproducts of food processing industries.

Proper infrastructure with facilities for sorting, grading, packaging, and post-harvest handling must be developed in all important markets and farmers must be well trained for effective management of agricultural produce during the post harvest phase.

INTEXT QUESTIONS 12.3

1. Maximum amount of post harvest losses is observed at

   a. Farmers' field b. Packaging

   c. Storage d. Transportation

2. The technique of applying ionizing radiation to fruits and vegetables is termed as ....

3. Which of the following materials is used to prepare edible coating for food wrap?

   a. Lipid b. Protein

   c. Polysaccharide d. All of the above

4. State whether the following statements are true or false.

   a. Higher concentration of O_2 and lower concentration of CO_2 are maintained in controlled atmosphere storage.

   b. Evaporative cool storage is ideal method to store crops for a shorter period of time.

Notes

WHAT YOU HAVE LEARNT

- Post harvest management focuses on preserving, processing, and adding value to agricultural produce to enhance its economic viability. The quality, duration of storage, and shelf life of agricultural crops can be improved by post harvest management system.
- The post harvest management system for agricultural produce includes production, protection, processing, packaging, distribution, marketing, and utilization as components of the post harvest chain aimed at fulfilling the population's nutritional needs.
- Major reasons for post harvest loss include poor planning, inadequate storage facilities, lack of good quality infrastructure and cold chain, inadequate packaging operations, limited awareness, insufficient technical support, knowledge gaps between lab and land, an unorganized market and insufficient marketing services.
- Advanced post harvest technologies like waxing, edible coatings, irradiation, evaporative cool storage, modified atmosphere packaging or controlled atmosphere storage may be employed to reduce post harvest loss.

TERMINAL QUESTIONS

1. What is the importance of post harvest management?
2. Explain the causes of post harvest losses of agricultural produce.
3. Describe the types of losses that occur during post harvest handling.
4. Enlist and explain various steps in the post harvest management system of an agricultural produce.
5. Discuss the negative effects of post harvest loss.
6. Write a short note on following topics
   a. Modified atmosphere packaging (MAP)
   b. Edible coating
   c. Controlled atmosphere storage

ACTIVITY

Imagine you are managing a kitchen storeroom at your home, where various food items such as grains, fruits, vegetables, spices, bread, jam, jelly etc. are stored. Discuss the potential risks associated with pest and disease infestation during storage and outline a strategy to mitigate these risks effectively.

....

....

....

ANSWERS TO INTEXT QUESTIONS

12.1

1. Post Harvest Loss
2. Tender texture (option d)
3. Mechanical loss, metabolic loss, pathological deterioration and poor storage facility

12.2

1. Quantitative and qualitative
2. Colour and texture

12.3

1. Transportation (option d)
2. Irradiation
3. All of the above (option d)
4. a) False b) True

Notes

GLOSSARY

Bruising: Bruising refers to the formation of larger, flattened areas on freshly harvested produce. A bruised fruit indicates cellular damage caused by its rough handling during harvest or post harvest phases. A major symptom of cellular damage due to bruising is internal browning.

Blanching: Blanching is a technique used to preserve the quality of vegetables before freezing. In this process, vegetables are heated in boiling water for a short period of time to stop enzymatic activity within it. However, it causes loss of nutrients, especially water soluble vitamins.

Pitting: This is the process of formation of small sunken area/pits on the surface of fruit. Pitting is primarily caused by mechanical impact or compression.

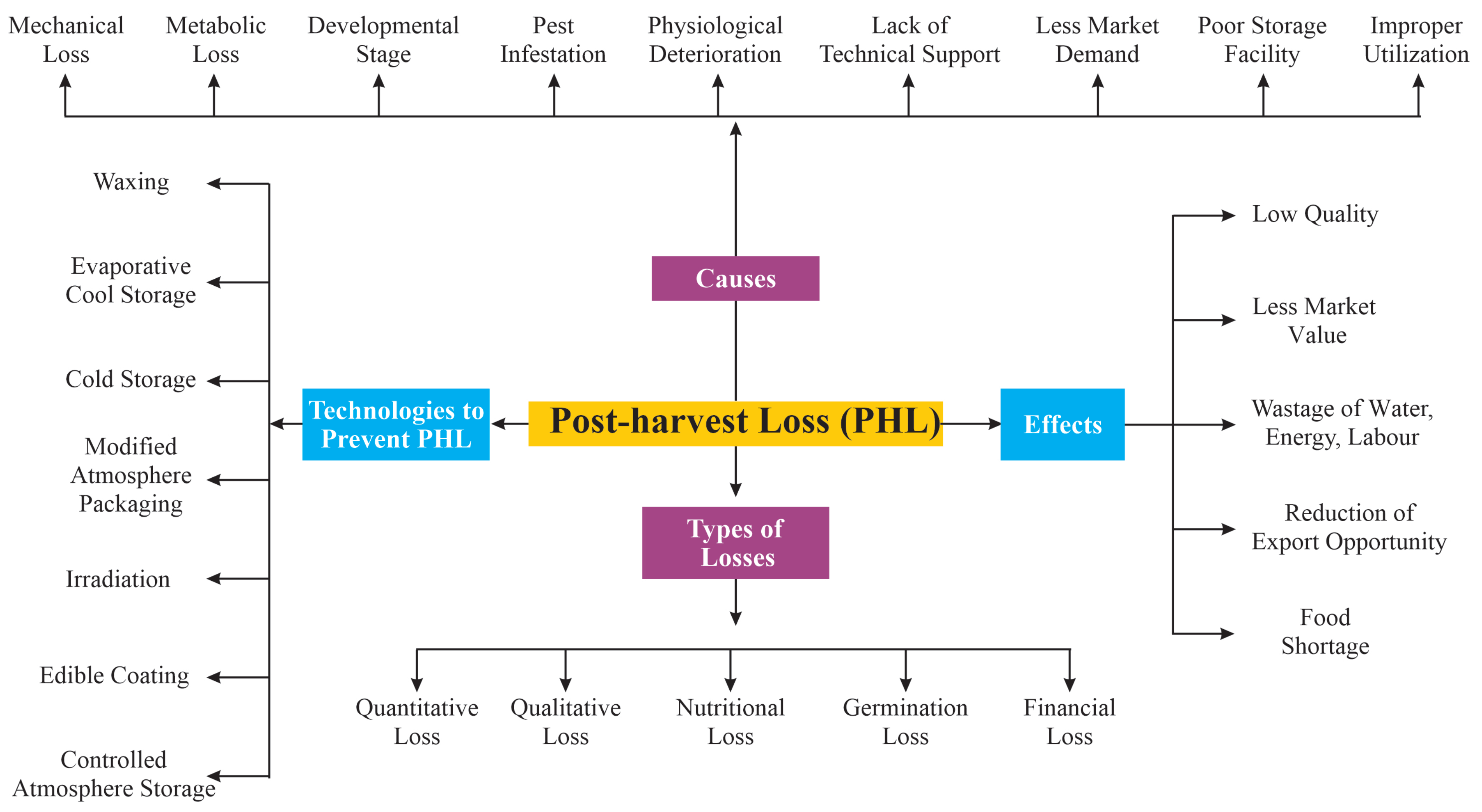
Ethylene: Ethylene is a gaseous plant hormone which plays a vital role in the ripening of fruits. An unripe fruit contains very little amount of ethylene. As the fruits matures, the production of ethylene increases, inducing the ripening process.

SUGGESTED READINGS

1. Simson, S. P. (2014). *Post Harvest Technology and Management*, Oxford Book Company, India.

2. *Importance of Post-harvest Management and Value Addition of Fruits and Vegetables*, Agricorn. (https://www.agricorn.in/2023/08/post-harvest-processing-fruits-vegetables)

WHAT YOU HAVE LEARNT



NOTE

13

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PROCESSES IN POSTHARVEST MANAGEMENT SYSTEM

The primary objective of post-harvest management system is to minimize losses or wastage of agricultural produce. In the current scenario of rising population and slow growth in agricultural production, the challenge is to ensure sustainable food security without harming the environment. Although agricultural crop output has expanded significantly in recent decades, the development and implementation of post-harvest technologies have lagged behind. Mechanical, microbiological, and physiological losses account for approximately 15% of post-harvest losses. The processing and value addition of extremely perishable commodities, such as horticultural produce, require timely attention and special interventions. Therefore, pre-harvest factors, harvesting, market preparation activities (including pre-cooling, sorting, grading, packaging, and on-farm storage), transportation, storage, value addition/processing, and by-product waste management are all crucial components of the post-harvest value chain and an integral part of the post-harvest management system.

LEARNING OUTCOMES

After studying this lesson, the learner:

- identifies various processes of post-harvest management system;
- describes the methods of fruits and vegetables processing; and
- explains the cereal processing techniques.

13.1 PROCESSES INVOLVED IN POST HARVEST MANAGEMENT SYSTEM

From harvest to consumption, food commodities often go through many post-harvest stages and procedures as given below:

Notes

1. Harvesting
2. Threshing (mainly food grains, pulses and oilseeds)
3. Drying
4. Transportation
5. Storage
6. Processing
7. Product quality control and standardization
8. Packaging (sealing, packaging and labeling)
9. Marketing (advertisements and distribution)
10. Product utilization (preparation and consumption of traditional dishes)
11. Buyer preferences (product evaluation, and consumer education)

Fig. 13.1: Processes/steps involved in post harvest management

13.1.1 Harvesting

The harvesting time of a crop depends on the degree of maturity, which is determined by crop-specific maturity indices. The goal of harvesting is to gather the produce from the field at the proper maturity with minimum damage. Maturity indices include 1) skin colour 2) form 3) shape 4) size 5) optical techniques (light transmission), 6) ripening,

Notes

and 7) hardness. When assessing the level of ripeness of fruits and vegetables, factors such as size, colour development, basic biochemical analysis, and the number of days from full bloom to harvest (DFFB) are also taken into account. For instance, the maturity index for oranges is the brix:acid ratio.

Harvesting of produce either before or after the optimal maturity stage can increase the risk of loss due to physiological or microbial factors.

13.1.2 Threshing

This procedure involves detaching the grain from the earheads or straw, using methods such as rubbing, beating, striking, or stripping. Threshing can be done either mechanically or manually. Traditionally, groundnuts are shelled by hand, while grains and pulses are threshed by beating them with a stick. The moisture in grains and the husk at the time of threshing is a critical factor. Mechanical and microbial damage are more likely to occur if threshing is done too early, particularly when the moisture content is high.

13.1.3 Pre-harvest drying

Proper pre-harvest field drying of cereals and pulses ensures good-quality preservation. However, it increases the risk of losses due to attack of birds, rodents, insects, moulds, and unfavourable weather conditions. Thus, proper care of the crop is required for protection from insect-pests.

13.1.4 Post-harvest drying

If grains are not dried properly and stored immediately in a granary, they are more prone to storage losses. Thus, it is necessary to bring the moisture content to optimum level (around 14%) through drying processes, such as sun drying, artificial dryers and shed drying. In case of cereals, the time required for drying is significantly influenced by weather conditions. Improper drying methods, such as using terraces, cribs, or unroofed threshing floors, can lead to damage from birds, small ruminants, and rodents. They deteriorate the quality of produce and may make the produce unmarketable.

A. Methods of drying

- **Natural drying:** This type of drying is done under the natural sun on rocks, mats, plastic sheets, or by hanging above fireplaces.

- **Artificial drying:** This process involves drying of grains or other produce in controlled environments with forced ventilation of heated air in specially

designed chambers or dryers. It is faster drying method particularly for high value produce.

B. Monitoring the drying process

Drying can be monitored using methods such as:

- Touching and tasting the grains
- Rubbing or walking on threshed grains
- Pressing grains with thumbs
- Observing physical appearance
- Gravimetric analysis
- Using moisture meter

C. Advantages of drying

Drying offers several benefits i.e. it reduces bulkiness, maintains viability of the harvested produce, lowers agricultural losses, reduces the risk of mould infection and aflatoxin contamination of seeds, minimizes storage grain pest infestation, extends the shelf life, and facilitates shipping and packing.

D. Disadvantages of drying

- Grain that is over dried becomes brittle and is more likely to shatter during processing (e.g., hulling, milling, or threshing).
- Damaged grain can be removed with the husk during winnowing and is more vulnerable to some insects and pests (e.g., flour beetles and weevils).
- Excessive drying of grain can lead to weight loss, reducing the sale value.

13.1.5 Transportation

A fully mature crop must be transported carefully to the threshing floor or collection site. Use elevated areas in field as a site for the threshing floor to avoid spoilage from unexpected rains. The produce must be transported in bags, baskets and open trolleys with proper care from the threshing floor to the grading and packaging facility, and then finally to the distant market. For long-distance transportation, covered wagons, bulk containers, and bags are commonly used. Transportation of perishable commodities is more challenging, and therefore need special care and carriers, such as proper packaging materials in trucks, cold storage, cold chain trucks, etc.

A. Precautions during transportation

- To avoid bruising, storage in godowns and cold stores must be done with proper care.
- Prevent excessive loading and inadequate handling
- Ensure adequate aeration while stacking the produce in trucks
- Take care during loading and unloading of the produce
- Select appropriate mode of transport and plan route effectively

INTEXT QUESTIONS 13.1

1. Maturity indices for orange for harvesting is
   a. TSS
   b. % Sugar
   c. % Acid
   d. Brix: acid ratio
2. What is threshing?
3. Name any two advantages of drying.
4. Write two precautions to reduce transportation losses.

13.1.6 Storage

For effective and long-term preservation, attention to hygiene, monitoring, and proper storage facilities is essential. Management of cleanliness, temperature, and humidity is particularly crucial in enclosed structures like granaries, warehouses, and hermetic bins. For example, mango, banana, and cucumber should be stored at temperatures of 8°C, 10-13°C, and 4-5°C, respectively. Farmers use various storage options including granaries, jute bags, clay pots, baskets, underground pits, metal drums, and bins or mud plaster bins.

A. Factors affecting the choice of granaries

a. The quantity of food produce to be stored

b. The duration of storage

c. The cost of storage infrastructure

d. The expenditure on construction

B. Precautions for a quality store

a. A quality store should protect the grain from rats, birds, poultry and domestic animals, while also allowing for cooling and drying.

b. Keep the livestock away from the store and clean any animal droppings from the surroundings to deter rodents

c. Stores should be located in areas not prone to water logging or natural floods.

d. Stores should not be positioned next to trees that could provide access points for rats and insects.

e. Avoid areas prone to strong winds that could harm the buildings or other infrastructure of the storage facility

f. Prevent roof-top leakage and maintain the store in good condition

g. The storage bins must be cleaned every time before filling grains. The used bags should be immersed in hot water and dried thoroughly to kill any insects present in it.

h. Conduct regular inspections of the store, ideally at weekly intervals

Notes

13.1.7 Processing

- **Primary processing:** It includes washing/cleaning, grading, sorting, dehulling, grinding, soaking, packaging, drying, winnowing, sieving, and milling.
- **Secondary processing:** This involves mixing, drying, cooking, frying, cutting, and extrusion product preparation.

13.1.8 Cleaning/winnowing

Unwanted, non-consumable substances like stones, soil, debris and other impurities in grains are removed through cleaning and screening operations. Winnowing is done to clean threshed crops by blowing in wind or using winnowing machines.

13.1.9 Sorting, Grading and Packaging:

These operations are majorly used for fruit and vegetables.

- **Sorting:** Removes diseased, bruised, rotten, bird eaten fruits or vegetables
- **Grading:** Ensures uniformity and quality by selecting healthy fruits and vegetables for marketing, sorted by size and colour
- **Packaging:** Fruits and vegetables are wrapped individually or in groups and packed in appropriate containers or boxes.

13.1.10 Packaging

Packaging is crucial for maintaining the quality of fresh horticultural produce until it reaches the consumer.

- Some vegetables like cauliflower and cabbages come from the field in large quantities with large portions of inedible parts. Prior to marketing, these inedible parts can be removed to cut down the transportation costs.
- Various vegetables, such as beans, peas, onion, garlic, okra, and potatoes, as well as many fruits, such as citrus, mango, and cull apples are packed using traditional packaging methods such as bamboo baskets, gunny sacks, and wooden baskets. However, boxes made up of corrugated fibre board are also utilized for packing of fruits like apples, stone fruits, oranges, grapes, sapota etc. whereas, most of the cut flowers are packed in cardboard boxes.

13.1.11 Marketing

Marketing is the last and most important step in the post-harvest system, which involves the movement of agricultural products from farm/field to the consumer. It is essential to form a link between farm products, retail chain, food industries and consumers.

INTEXT QUESTIONS 13.2

1. For the best storage of mangoes, temperature should be

   a. 6°C

   b. 8°C

Notes

c. 5°C

d. 3°C

2. The most appropriate packaging material used for cut flowers is

a. Plastic boxes

b. Caretes

c. Wooden boxes

d. Cardboard boxes

3. Used bags in store should be immersed in ……………….. to kill insects.

13.2 PROCESSING OF FRUITS AND VEGETABLES

13.2.1 Primary Processing of Fruits and Vegetables

Fruits and vegetables can be prepared for immediate marketing using straight forward basic processing procedures including sorting, grading, trimming, surface drying, washing, and packaging. Various technologies and equipments are available for these primary processing tasks including farm-level fruit and vegetable washing machines, hydro cooler-cum-washers, basket centrifuges, tamarind dehullers and deseeders, pomegranate aril removers, washing and polishing machines, cleaner-cum-graders. These tools facilitate efficient processing and preparation of produce for market readiness.

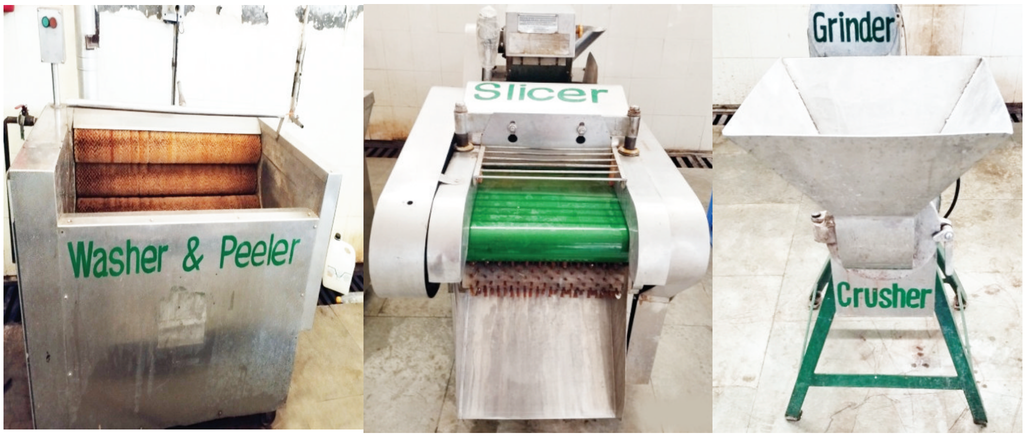


Fig. 13.2 Primary processing equipments
a) washer & peeler b) slicer c) crusher

13.2.2 Secondary Processing

1. **Drying:** It is a commonly used and cost-effective method for preserving horticultural produce. Aromatic or medicinal plants can be dried using mechanical, poly tunnel, or sun dryers. For example, vegetables are typically dried to a moisture content of 3-5 %.

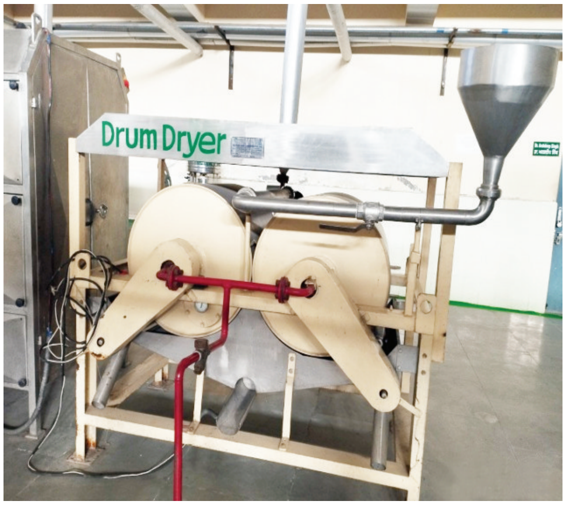


Fig. 13.3a

Fig. 13.3b

*Fig. 13.3 Drying equipments **a)** drum dryer and **b)** spray dryer*

2. **Osmotic dehydration:** This process involves the partial removal of water by immersing the produce in sugar syrup, followed by drying in a mechanical dehydrator. Currently, osmotic dehydration is a widely acknowledged method for creating products with satisfactory sensorial quality and intermediate moisture levels.

Notes

3. **Processing of lesser utilized fruits:** Fruits such as aonla, bael, aloe vera, and jack fruit are often processed because they cannot be consumed in large quantities in their natural state. Products made from these fruits include high-fiber and antioxidant-rich drinks, cashew apple powder mixed with 2% cereal flour (for strength), beverages like ripe bael drink, RTS (ready to serve), squash, aloe vera gel, etc.

4. **Value addition:** Fruits and vegetables that cannot be sold fresh can be transformed into a variety of products through value addition. Examples include juice concentrates, canned fruits, fruit-based carbonated juices, pickles, pulp extraction, chutneys, preserves, sauces, sweets, RTS beverages, squash beverages, and appetizers.

Fig 13.4a

Fig 13.4b

Fig. 13.4 Value addition equipments a) grinder and b) pulper machine

5. **Fermented products:** The fermentation of fruits into alcoholic drinks is an established practice for utilization of different fruits.

   a. Champagne (sparkling wine), Brandy, and Still wine: These are commercially produced from grapes.

   b. Other fermented beverages: Cider, wine, and vermouth can be prepared from fruits like apples, apricots, plums, wild apricots, strawberries, and peaches.

   c. Fermented vegetables: Sauerkraut and sauerruben are prepared from cabbage and turnip, respectively.

6. **By-product waste utilization:** Fruit processing industries generate significant amount of waste in the form of pomace (residue left after juice extraction), stones/pits, seeds, and peel. These by-products can be utilized to create a variety of value-added products:

   a. The extraction of pectin, dietary fibre, and industrial alcohol using pomace.

   b. Fruit seeds or stones left after fruit processing can be used for oil extraction, whereas fruit pulp can be used in culinary preparation, and medicines.

   c. Peel oil, peel candy, pectin powder, and animal feed are some of the products produced from citrus peels.

INTEXT QUESTIONS 13.3

1. Sauerkraut is a fermented product of

   a. Cabbage

   b. Radish

   c. Turnip

   d. Beetroot

2. The byproducts generated after fruit processing are ....

3. The correct value of moisture content in dried vegetable is

   a. 6 %   b. 7 %

   c. 5 %   d. 8 %

Notes

4. Which fruit is commonly used to make champagne?

13.3 PROCESSING OF CEREALS

13.3.1 Primary Processing of Cereals

It involves several steps including cleaning, sieving, hulling, grading, milling, tempering, grinding, soaking, parboiling, and drying. The milling process turns grains into flour, which is used to prepare various value added products such as bakery items and extruded products. Cereal flours are essential in the production of bread, breakfast cereals, and snack items (extruded snacks) made from major crops like wheat, maize, rice, oats, barley, millets and sorghum.

A. Wheat Flour

Wheat flour contains protein known as gluten. When preparing leavened bread, the ability of gluten to form elastic network within the dough is quite helpful. The gas that yeast releases during fermentation is entrapped by the protein network. This results in increasing the dough volume and form bread with light texture. When leavened bread is made with low-gluten flour, the gas escapes, resulting in flat and heavy bread. There are many grades of wheat flour depending on how much of the whole wheat grain is removed.

B. Cassava Flour

It is fine white flour that is made from cassava tubers. It is common flour used in the preparation of various fried and baked products, such as bread, biscuits, and cakes.

C. Maize Flour

It is generally used to prepare tortillas, and extruded snack foods.

D. Sorghum Flour

Typically, sorghum flour is used to make porridge.

E. Soy/Composite Flour

Soy/composite flour is used to enhance the protein content and balance the amino acid composition of other cereal or pulses flours, such as maize flour. It serves as both a weaning food and in porridge.

F. Special Baker's Flour

This is also known as bread-making flour. These are used to make bread, rolls, and pastries. It requires a high amount of gluten to be present in baking flour for the creation of light and airy bread.

Various extraction rates of flour can be found in the following:

1. Whole grain flour: 100% extraction (used for brown bread and high fibre products)
2. Wheat meal flour: 90- 95% extraction
3. Straight run flour: 70-72% extraction

13.3.2 Secondary Processing of Cereals

Secondary processing of cereals involves adding value to primary cereal products such as whole grains, flakes or flour. This process uses these base materials to create a variety of products and diversify dietary options.

The common techniques in secondary processing of cereals include baking, fermentation, flaking, puffing, frying, and extrusion.

A. Puffing: Puffed grains are often consumed as snacks or breakfast cereals. The process of puffing involves applying extremely high steam pressure to grains, causing them to expand and "pop" (the grain to explode and turn inside out). The puffed grains can be further processed by coating, toasting, or mixing with other ingredients.

Fig 13.5 Puffed rice

B. **Flaking**: It involves partially cooking of grains in steam to soften them, followed by rolling or pressing them into flakes and drying. The resulting flakes should have a moisture content of less than 7% and be consumed crisp. This process turns grains into ready-to-eat (R-T-E) products.

Fig. 13.6 Flaked rice

C. **Fermentation**: A variety of processed products can be produced by fermenting cereal flour. Fermented products include bread, beer, soy sauce, and other items made from cereal flours, grains, and baking batters and doughs.

D. **Extrusion**: Extrusion is the process where dough is heated and forced through a small hole to create specific strands or structures, which are then dried. The extruded products can undergo additional processing such as frying, drying, or boiling. Pastas, noodles, and breakfast cereals are examples of extruded foods.

INTEXT QUESTIONS 13.4

1. Flour is produced through the process of
   a. Drying
   b. Milling
   c. Parboiling
   d. Sieving
2. Protein present in wheat flour is ………………………..
3. Secondary processing of cereal includes ………………………

4. Which type of flour is used to increase protein content in cereal flour?

   a. Soy flour

   b. Maize flour

   c. Cassava flour

   d. Wheat flour

Notes

WHAT YOU HAVE LEARNT

- In developing nations like India, the expansion and growth of agricultural value chains for domestic and international markets can be seen as a potent tool for eradicating poverty and addressing the problem of food security.
- India is one of the world's major producers of agricultural produce. India is the world's top producer for spices, lentils, sugarcane, milk and also the second-largest producer of grains, fruits, and vegetables. But huge post-harvest losses in crops are caused by several factors, like the perishability of the commodities, the farmers' poor economic situation, the lack of production planning, lack of infrastructure for cultivation, storage, and packaging operations, and inadequate post-harvest handling facilities.
- Post harvest management is a strategy used on agricultural products after harvest for protection, preservation, processing, packaging, distribution, marketing, and utilization to meet the population demands for food, nutrition, and financial security.
- From a broader perspective, it involves a number of operations, including grading, post-harvest processing, waste management, labelling, packaging, storage, and marketing.

TERMINAL QUESTIONS

1. Enlist and explain the various steps in post harvest management system.
2. Differentiate between primary and secondary processing techniques.
3. What are the disadvantages of over drying?

Notes

4. How is process of drying monitored?

5. What is flour? Describe various types of flour.

6. What are the factors that need to be considered during the choice of granaries?

7. Discuss secondary processing of fruits and vegetables.

8. What are the techniques for secondary processing of cereals? Explain in brief.

ACTIVITY

Conduct the shelf-life study of the following food products. Keep the food product as it is and observe how the appearance of food material changes over the period of time. Take note of number of days required for each of the food to become unfit (rotten/spoiled) for human consumption.

....

....

....

Food type	Observed changes during the study	Number of days until spoilage
Milk		
Mango		
Apple		
Potato		
Puffed rice		
Wheat flour		

ANSWERS TO INTEXT QUESTIONS

13.1

1. Brix: acid ratio (option d)
2. Threshing is a procedure of rubbing, striking, or stripping to separate grain from the plant.
3. Drying decreases the bulk volume of the produce and lowers the risk of mould infestation in seeds.
4. Avoid excessive loading and proper aeration to the stored products

13.2

1. 8°C (option b)
2. Cardboard boxes (option d)
3. Hot water

13.3

1. Cabbage (option a)
2. Pomace, stone/pits, seeds and peel
3. 5% (option c)
4. Grape

13.4

1. Milling (option b)
2. Gluten
3. Baking, fermentation, flaking, puffing, frying, and extrusion
4. Soy flour (option a)

Notes

GLOSSARY

Dehulling: It is the process of removing the hull or outer covering of any grains or seeds. Dehulling can be performed for several types of grain like rice, soybean, etc.

Squash: It is a non-alcoholic beverage containing at least 25% fruit juice or pulp and 40-50% TSS (total soluble solid). Squashes are diluted before serving.

Ready-to-serve (RTS) beverage: This is type of fruit beverage that contains minimum 10% fruit juice and 10% TSS (total soluble solid). This beverage is called RTS because they are not diluted before serving.

Vermouth: This is a type of wine fortified with herbs or botanicals. It is used for medicinal purposes.

Cider: Cider is an alcoholic beverage made from fermented apple juice.

Tortilla: A thin, circular unleavened/unraised flat bread made from maize flour.

Porridge: A soft and thick dish made from boiling grains or legumes in water or milk. Usually, it is served hot during breakfast. Most common example is oatmeal or oat porridge.

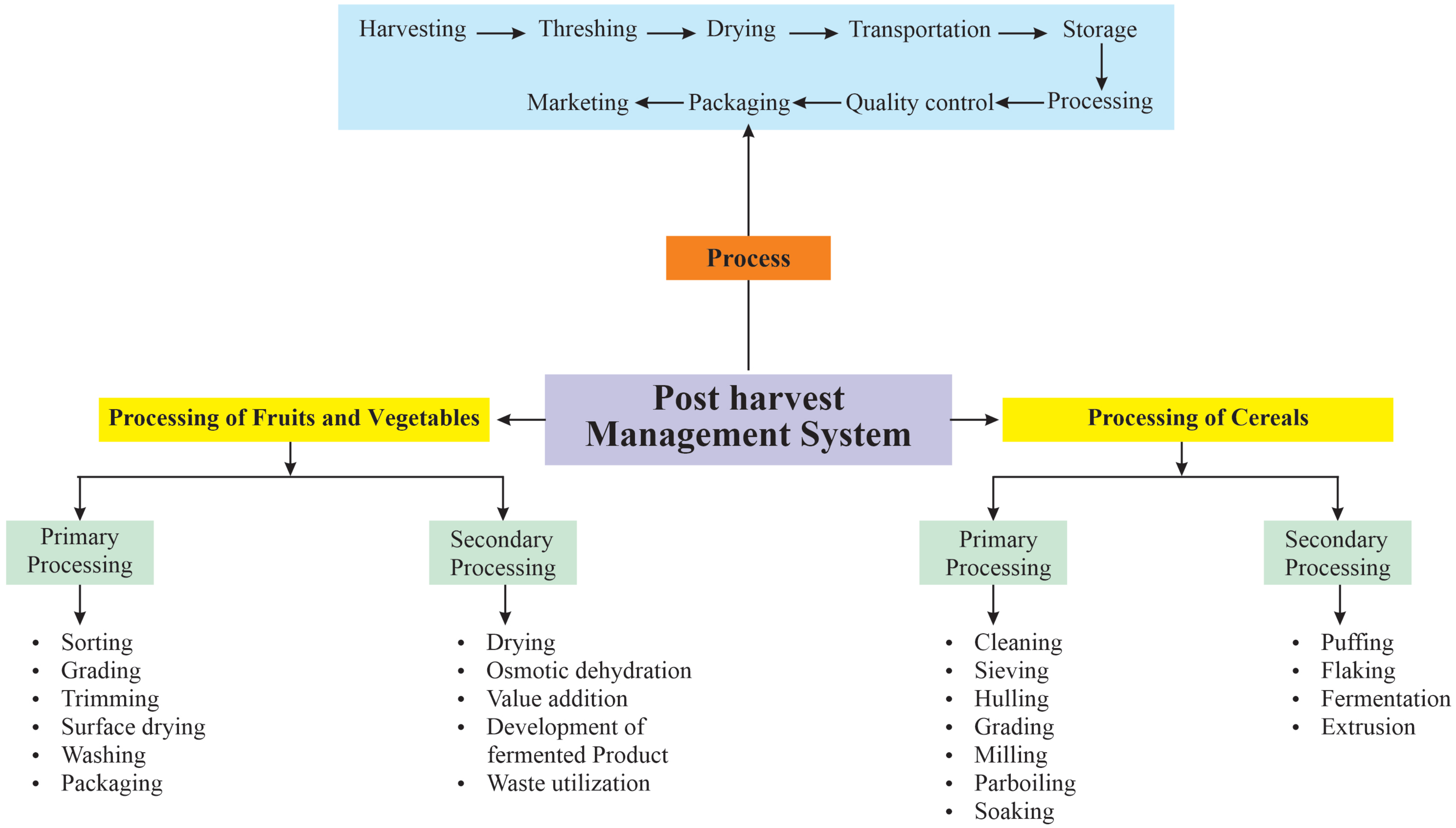
SUGGESTED READINGS

1. Scott, S. (2022). *Introduction to Postharvest Management*, Murphy & Moore Publishing, USA.

2. Baxter, E. (2019). *Postharvest Management*, Callisto Reference, USA.

3. Hasanuzzaman, M. (2014). *Postharvest Technology*, www.hasanuzzaman.webs.com. (https://hasanuzzaman.weebly.com/uploads/9/3/4/0/934025/postharvest_technology.pdf)

WHAT YOU HAVE LEARNT



NOTE

14

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STORAGE AND WAREHOUSING

Do you know that saving and serving food is a service to humanity. A significant part of the human population in the world does not have enough food to meet their daily needs. Countries like China, United States of America, India, Australia, Canada etc. are producing enough foods to meet their people's needs, but many countries depend on imports from food-surplus nations. Besides, some states in India like Punjab and Haryana produce huge quantities of food grains. These food grains are harvested during specific crop seasons such as *Kharif* and *Rabi* in India; however, their demand remains year-round. So, it becomes necessary to store food grains not only to ensure year-round domestic supplies but also to meet export obligations to other needy countries. Similarly, perishable commodities such as seasonal fruits (apple, oranges) and vegetables (potato, onion, garden peas, carrots) also need proper storage for regular supplies in local and export markets. Proper storage ensures a steady supply and regulates market prices, which are essential for healthy market situation. However, despite the importance of food storage for domestic and export markets, there is not enough attention given to creating and maintaining proper storage facilities. As a result, post-harvest loss of food products is very common in India. It is estimated that around one-third of the food produced in India is wasted due to improper storage. In this lesson, you will learn about various methods to store food for longer period of time.

LEARNING OUTCOMES

After studying this lesson, the learner:

- defines the storage and its importance;
- explains the important factors of food storage;
- indicates several precautions for prolonged storage of foods;

Notes

- identifies the difference between traditional and modern storage structures; and
- describes warehouse and its system of food storage.

14.1 IMPORTANCE OF STORAGE

Food is a perishable commodity, and it must be kept in a favorable environment after harvesting to avoid post-harvest losses. Post-harvest losses refer to the loss in quality or physical attributes that occurs after harvesting the crop until its consumption. This situation is more serious in developing countries, where on one side, people are facing severe hunger and malnutrition, and on the other, the produced food is being spoiled due to lack of infrastructure and inadequate technology for storage. If the harvested products are stored properly, both the farmer and consumer can benefit in following ways:

- Reduction in the fluctuations of market price of the commodity
- Availability of a wide range of food products in the market
- Consumers can enjoy seasonal products throughout the year, mainly during the off-season
- Better economic return to the farmers or producers

14.2 FACTORS OF STORAGE

Several factors influence the storage life of food produce. These are:

A. Temperature

Optimal temperature after harvesting greatly increases the shelf life of the produce. Usually, lower temperatures are preferred for long-term storage of food. The optimum temperature of storage varies with the type of food stored. Some food items are more perishable and require refrigeration temperature, while others need temperature above refrigeration to keep them well. Reduction in the rate of spoilage during low-temperature storage is attributed to lower respiration rates of fruits and vegetables and reduced microbial activity. It is essential to keep in mind that very low temperatures during storage can harm the produce and cause 'chilling injury'.

B. Humidity

An optimum level of humidity is required in the surroundings for stored food items for maximizing their storage life. Fruits and vegetables should be kept at 80-95% humidity to maintain their freshness for a long period of time. High temperature coupled with high humidity is the most ideal condition for microbial attack. Therefore, both factors should be monitored to maximize longevity.

C. Moisture

All fresh foods have a certain amount of moisture present inside them. It varies greatly depending on the type of food. Fruits and vegetables are usually high in moisture, while grains contain less moisture. A general rule is that the lower the moisture content of the food item, the longer is the storage life. Therefore, drying of food items to a certain level of moisture content is done prior to storage, which enhances their storage life.

D. Length of storage

Many food items are seasonal in nature. There is a fixed period in a year during which they are available. To relish them throughout the year, they need to be stored for a much longer period of time which requires special conditions to sustain them. For long storage periods, usually cold storage is done. It maintains temperatures around 0°C.

E. Other factors

Post-harvest disease, damage caused due to pressure of overfilling packages, package failure causing collapse of bottom layers due to excessive stacking, and moist cartons boxes are all factors that affect how long crops can be stored.

INTEXT QUESTIONS 14.1

1. Post harvest loss of harvested products is severe in developed countries (True/False).
2. State any two benefits of storage of fruits and vegetables.
3. For long term storage of food, ... temperature is preferred.

4. To maintain freshness, fruit and vegetables are stored at humidity of

   a. 10 – 20%

   b. 30- 45%

   c. 55 – 60%

   d. 80 – 95%

5. What should be the moisture content of food for long-term storage?

14.3 PRECAUTIONS FOR FRUIT AND VEGETABLE STORAGE

14.3.1 Precautions Before Storage:

Several precautions need to be taken before final storage of produce in order to enhance the shelf life of products:

- Immediately after harvesting, the perishable agricultural commodity should not be exposed to high temperatures or laid in direct sunlight, which can decrease the storage life of the produce. Vehicles with the produce should not be parked in full sun. To avoid these conditions, transportation during the night or before dawn is practiced for highly perishable commodities. The cold supply chain is best for safe transportation of such produce, which is in the infancy stage in our country.

- There should be a facility of a shed or room near the farm for keeping the freshly harvested produce. Thereafter, the produce should be transferred to the storage facility as soon as possible.

- Fruits and vegetables need to be handled carefully as slight mishandling might damage them, leading to a reduction in quality or complete deterioration due to microbial attack.

- To minimize vibrational damage during transportation, the produce should be packed properly using cushioning materials.

- Avoid using wet packaging materials and packing of wet items (free from surface wetness) in cartons; otherwise, this will deteriorate the product, and collapse the package, and ultimately leads to spoilage of the produce.

- Proper cleaning and drying up of the produce to a safe moisture level before moving it inside the storage area can help check the microbial infestation.

- Sorting of the harvested produce should be done to remove damaged or diseased items; otherwise, they will damage the whole lot. Grading of fruits according to weight, color, size and maturity is also practiced. Pricing of the produce varies widely according to the grade or quality of the product.
- Emerging technologies like modified atmospheric packaging (MAP), where the atmosphere inside the package is modified to reduce the rate of respiration, transpiration, and browning, may be adopted for highly perishable crops. However, it is a costly process and requires careful supervision of other factors.

14.3.2 Precautions During Storage:

- The area for handling and storage of produce should be maintained in a hygienic condition with frequent cleaning and repair.
- Timely fumigation and disinfection should be done to reduce microbial and insect-pest infestation.
- All the holes of storage area should be properly covered to avoid entry of insects, rats and dust particles.
- Humidity control inside the room should be done as frequent changes in the level of humidity could lead to deterioration in the product quality.
- The floor should be cemented or tiled properly to avoid infestation from soil-borne microbes and insects.
- Bags should be placed on wooden or bamboo crates to avoid contact with the floor and to keep away moisture.
- Poison baits and cages should be employed to combat the risk of rodent infestation.
- Old and new stocks should be stored separately. First-in-first-out principle should be used to remove old stock.
- Proper air circulation should be maintained through all the bags.
- Drying in the open space should be avoided as it may lead to contamination.
- Regular checks of stored items are necessary to avoid insect infestation or deterioration.

- All the pipes and ducts of the warehouse should have mesh on their openings to avoid the entry of insects and rats.
- Proper lighting should be done to monitor entry of insects and other problems.

Notes

INTEXT QUESTIONS 14.2

1. What is the main purpose of forming a shed near the farm?
2. Why is exposure to high temperature avoided for freshly harvested farm products?
3. The practice that is performed to reduce microbial infestation
    a. Cleaning
    b. Drying
    c. Fumigation
    d. All of these
4. Poison bait and cages are employed to reduce the attack of ....

14.4 CHANGES IN THE FOOD DURING STORAGE

During storage, food undergoes several changes due to internal (e.g. respiration) as well as external factors (e.g. pest attack). These changes can affect both the quality and quantity of the product. These changes may be categorized as:

I. Physical changes

a. Change in shape and size

b. Cracking

c. Formation of clumps

II. Chemical changes

a. Browning

b. Dehydration

c. Absorption of moisture

d. Degradation of protein, vitamins, or antioxidants

e. Oxidation of lipids

III. Biochemical changes

a. Alteration in flavor and colour

b. Textural changes

14.4.1 Cause of Changes in Grain During Storage:

- **Respiration:** The freshly harvested produce respires and releases carbon dioxide along with water and heat energy. This causes grains to clump together, leading to quality deterioration, handling challenges and economic loss. Moreover, the release of moisture favors the growth of pests and microorganisms, leading to a reduction in food quality. This moisture can also condense on the roof of the storage bin, causing localized grain spoilage.

- **Microbial attack:** Abiotic factors like moisture and temperature play an important role in the microbial infection of stored foods. Fungal spores enter the storage area through the air, along with foods, contaminated bags or equipments and manual mishandlings of the stored food. They are able to flourish on the surface of the food when appropriate conditions are provided.

- **Insects:** Beetles and moths are the most common insects encountered in the stored food produce. They can flourish when optimum conditions are provided. Infestation by the insects may result in:

  - Development of an unpleasant odor and taste due to contamination with their excreta.
  - Increase in temperature and moisture content of the produce.
  - Discoloration, pitting, and powdering of grains, leading to an overall deterioration in quality.
  - Reduced nutritional quality of produce.

14.4.2 Losses in Food:

Food losses are mainly of two types:

1. **Direct losses:** Direct losses refer to the immediate and tangible reduction in the quantity of food due to various factors. Direct losses include spillage, pest infestation, spoilage and damage, etc.

Notes

2. **Indirect losses:** Indirect losses refer to the reduction in the quality and usability of food, which are quite significant, and vary greatly depending upon several factors, including consumer preferences and perceptions. Indirect losses include nutritional degradation, textural changes, flavour deterioration, appearance changes and contamination.

INTEXT QUESTIONS 14.3

1. Which of the following changes is due to chemical process in food?
   a. Cracking
   b. Clump formation
   c. Change in shape
   d. Browning
2. What is the reason of clump formation of food products?
3. Two main types of losses are .... and ....

14.5 STORAGE TECHNIQUES

Storage is a crucial factor in increasing the shelf life of agricultural crops and in controlling transportation and market supply. Storage facilities must provide adequate protection for stored foods against biotic factors such as insects, pests, rodents, birds, and microbes as well as abiotic factors like bad weather, high temperatures, heavy rainfall, etc.

14.5.1 Types of Storage in India:

Storage structures in India may be divided into two types: 1) Traditional and 2) Modern

A. Traditional storage

In India, majority of the grains produced are stored using traditional methods, which do not adequately protect them from biotic and abiotic factors. Moreover, produce cannot be stored for a long period of time in these structures. Examples of traditional storage include **earthen pots**, **mud bins**, **underground pits**, and **maize cribs**. Handmade storage structures made up of mud like earthen pots or mud bins are commonly found in different regions, often with local names.

Other structures such as **baskets** are made from locally available materials like leaves and bamboo. Fruits and vegetables are usually stored in **wooden boxes** and covered with straw to prevent damage from mishandling or sudden shocks.

Farm-level storage facilities with capacities ranging from 100 kg to a few tonnes are created for storing food grains. Other storage structures made from plywood, ferro-cement, metal, and high-molecular weight high-density polyethylene (HMHDPE) are also suitable for storage.

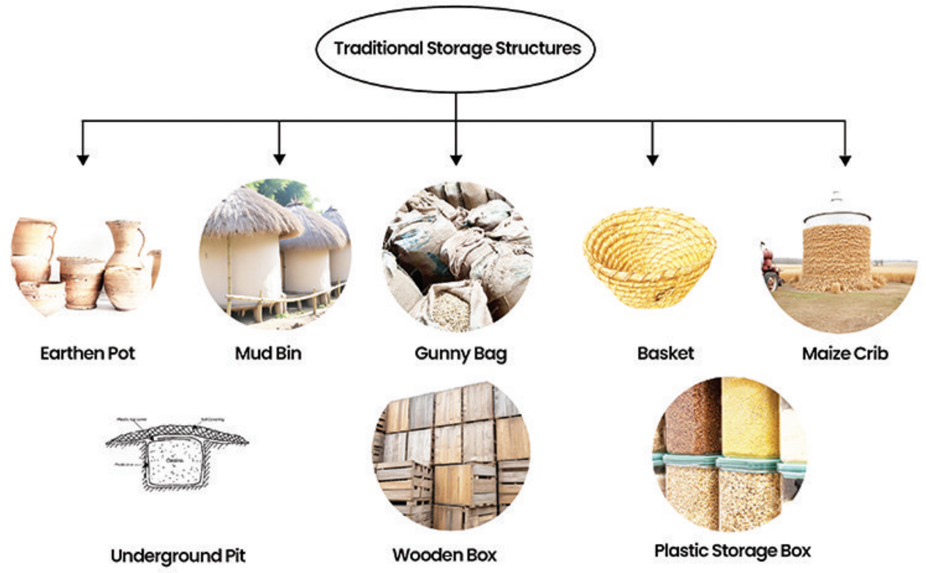


Fig. 14.1: Traditional storage structures

B. Modern storage

a. Covered storage: This is the most common method of storing grains. It involves packing grains in jute bags, which are then piled in warehouses.

b. Cover and Plinth method (CAP): In India, when traditional godowns and silos are full, bag stacks are constructed outside on a raised platform (plinth), and aerated at least once a week by moving the covers to the seventh or eighth layer. Wheat and paddy are currently stored using this method. However, a major disadvantage of the CAP method is that the food grains cannot be efficiently fumigated, and the coverings are susceptible to damage from wind and rain.

c. Silos: These are tall towers specially designed for storing grains. They are considered one of the most efficient methods for storing grains as they require less land and operate round the clock. The most common shape used is the deep silo.

Notes

d. **Silo bag technique:** This technique involves the use of hermetically sealed (airtight) plastic bags. The primary advantage of these bags is that they protect the grain from insects, pests, rain, humidity, sun, and dust.

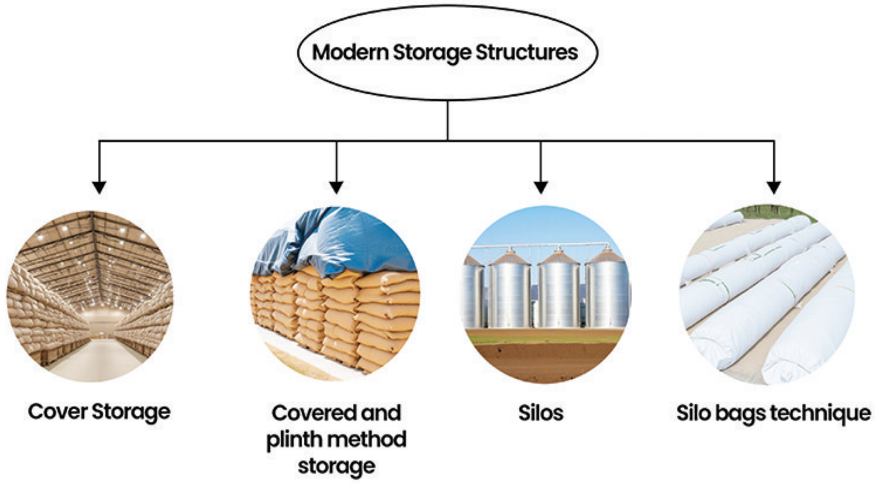


Fig. 14.2: Modern storage structures

Although many other storage options are available, the majority of agricultural produce is typically stored using an air-cooled system. Controlled ventilation and dehumidifiers are sometimes used to manage the humidity of the storage area. Cold storage, also known as refrigerated storage, involves controlled temperature and humidity to extend the shelf life of produce. Zero energy cooling is a well-known low-cost storage structure. Storage under a controlled atmosphere (3-5% O_2 and 2-5% CO_2) reduces peel browning and decreases the loss of soluble solids, acidity, and ascorbic acid.

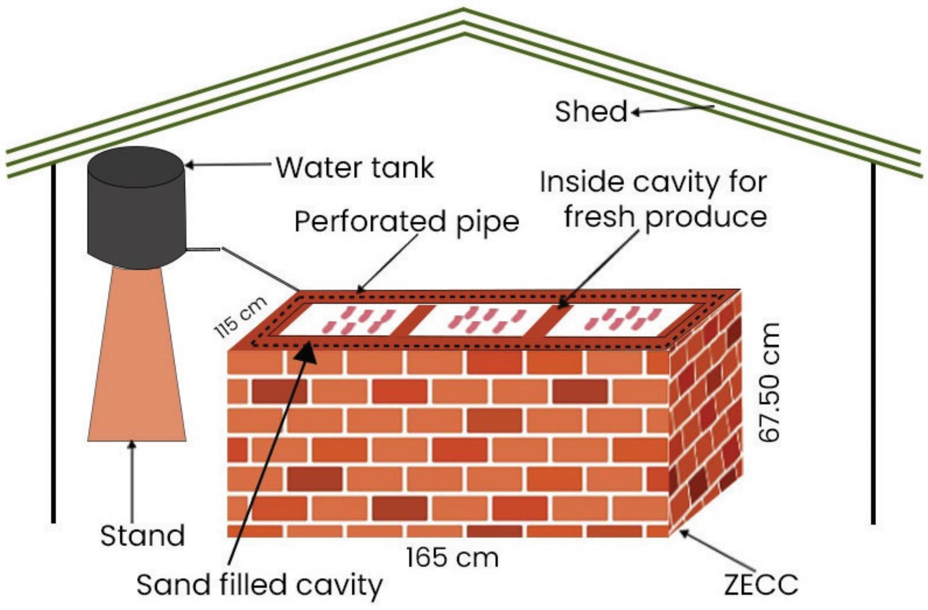


Fig. 14.3: Zero energy cool chamber (ZECC)

Grain storage in typical warehouses is done using gunny bags, polypropylene bags, silos, flat storage facilities, and elevators. The benefits of a bagged storage system include lower initial investment costs and no requirement for complex aeration circulation and fumigant systems. In addition to warehouse storage, other grain storage options exist, such as bulk storage. Bulk storage is carried out in hopper- or flat-bottomed bins, bunkers, and silos with varied capacities, made of brickwork, wood, shatterproof concrete, or metal. However, flat-bottomed bins offer more storage space and are less expensive to build.

Outdoor storage structures are frequently used when:

- There is a shortage of space in permanent storage facilities.
- The cost of constructing new building is too high.
- There is excess production in areas where adequate transportation to relocate the stocks is not available.

14.6 WAREHOUSE

The warehouse building is primarily a single-storey structure with minimal interior walls or partitions, a roof supported by trusses, and the presence of industrial equipment like a crane inside the structure. These warehouses are primarily designed for bulk storage.

A warehouse storage system is a collection of structures specifically designed to optimize space usage and improve organization, ensuring effective use of warehouse space.

Fig. 14.4: Interior of a warehouse

14.6.1 Typical Structure of A Warehouse:

1. The most prevalent elements are the vertical long walls with a sloped roof supported by horizontal girts joined to the columns if metal sheathing is used.
2. The building material should be weatherproof, corrosion-resistant, and fireproof.
3. An appropriate bracing system is essential to withstand lateral stresses.
4. Rigid-framed warehouse buildings are typically linear, traditional developments of plane frames that can withstand external loads. Rigid frames can be single-storied or multistoried.

14.6.2 Importance of Warehouse System

- **Improved safety:** Modern warehouse storage systems are safe and well-engineered. These buildings are sturdy and long-lasting enough to hold large quantities at once.
- **Enhanced organization:** The warehouse layout is designed to optimize storage conditions. It allows for alterations in structures to meet specific storage requirements.
- **Maximum space utilization:** All resources and space are utilized effectively for the storage of products.

The Government of India is emphasizing on building a strong warehousing system in the country for food grains to store as buffer stock. It is essential for meeting contingency situations such as natural calamities that affect production. A robust warehousing system also helps in maintaining market prices.

INTEXT QUESTIONS 14.4

1. Give four examples of traditional storage structures.
2. CAP stands for …………………………..
3. What is the full form of HMHDPE?
4. Tall towers specially constructed for storing grains are termed as ………………
5. What is a warehouse?

WHAT YOU HAVE LEARNT

- Food is a perishable commodity; therefore, it must be kept in a favorable environment after harvesting to reduce losses. Proper storage of harvested products is beneficial to both producers and consumers.
- Temperature, moisture, humidity are some of the critical factors affecting the storage of food products. Generally, low temperatures, low moisture levels, and high humidity are preferred for long-term storage.
- In India, traditional storage structures like earthen pots, mud bins, and underground pits are mainly used for storing grains. Fruits and vegetables are usually stored in wooden boxes.
- Modern storage techniques include covered storage, cover and plinth method, silos and silo bag technique, which offer good protection from biotic and abiotic agents.
- Warehouses are large, plain buildings used for bulk storage of food.

TERMINAL QUESTIONS

1. Write a short note on storage and warehouse.
2. Discuss the important precautions that need to be taken during storage.
3. What are the types of food loss? Give a brief description of them.
4. What are the different types of modern storage methods?
5. What are the factors affecting the storage life of food?
6. What are the different types of changes that occur during food storage? Explain the reason for such changes.
7. State the conditions when outdoor storage is practiced.
8. Discuss the importance of the warehousing system.

Notes

ACTIVITY

Take photographs of various storage facilities and warehouses in your nearby area and describe in your own words the various storage facilities used for different food products.

....

....

....

ANSWERS TO INTEXT QUESTIONS

14.1

1. False
2. Reduction in the fluctuations of market price of the commodity and availability of seasonal products in market throughout the year
3. Low
4. 80-95% (option d)
5. Low moisture content

14.2

1. To avoid exposure to direct sunlight to harvested products
2. For increasing storage life of produce
3. All of these (option d)
4. Rats

14.3

1. Browning (option d)
2. Respiration of freshly harvested products
3. Direct and indirect

14.4

1. Earthen pot, mud bin, underground pit, basket
2. Cover and plinth
3. High molecular weight high density polyethylene
4. Silos
5. Warehouse is a large plain building used for bulk storage of foods.

Notes

Notes

GLOSSARY

Warehouse: The warehouse building is primarily a single-storied structure with minimal interior walls or partitions and a roof supported by trusses. These are primarily created for bulk storage.

Silos: These are tall towers specifically designed for storing grains. Silos require less land and operate round the clock.

Cover and plinth method (CAP): In this method, stacks of bag are constructed outside on a raised platform (plinth) and covered with some waterproof material.

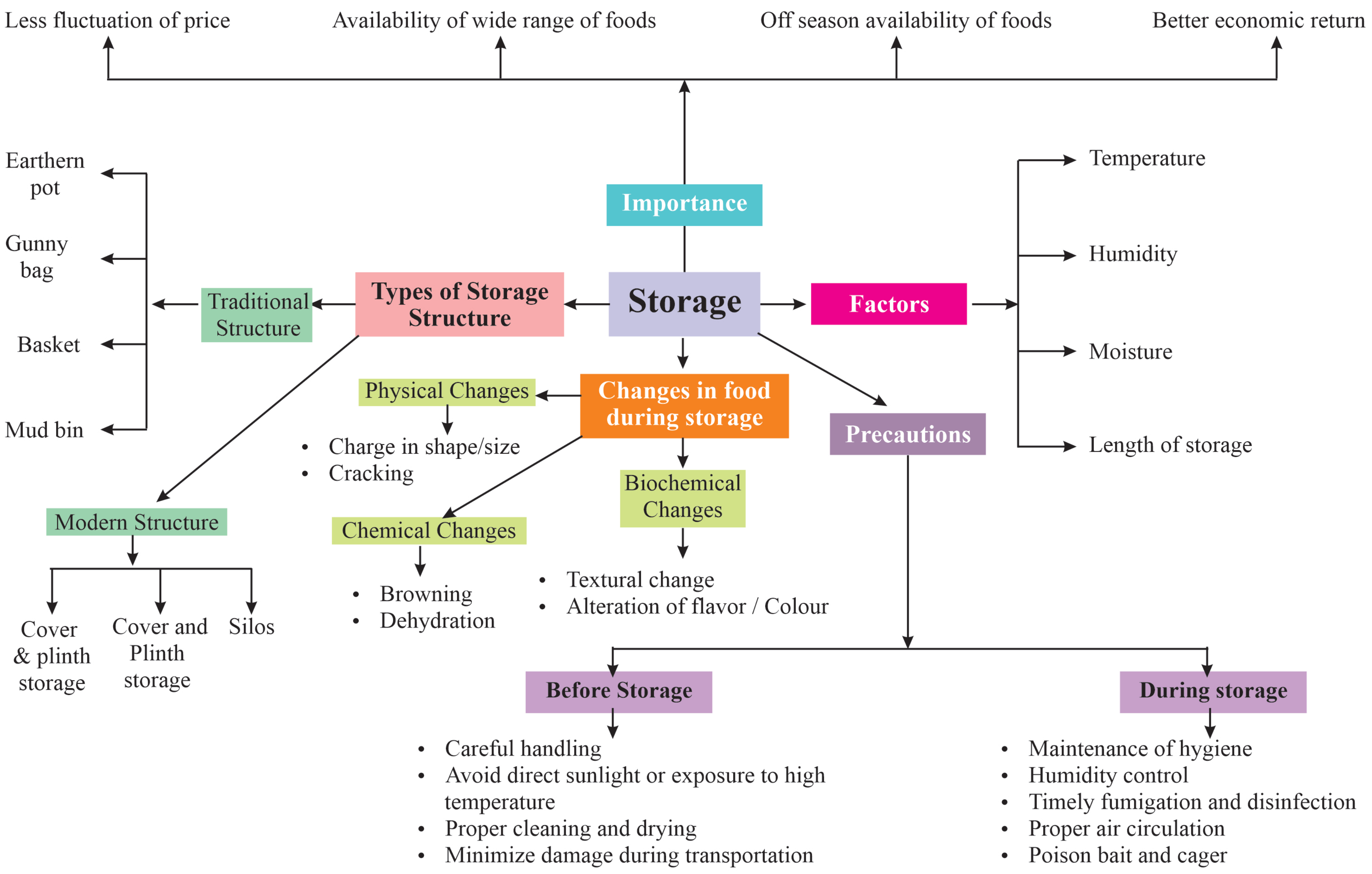
SUGGESTED READINGS

1. *Agricultural marketing: storage and warehousing*, TNAU Agritech Portal, Tamil Nadu Agricultural University, Coimbatore, India. (https://agritech.tnau.ac.in/agricultural_marketing/agrimark_storage%20and%20ware%20housing.html)

2. *Storage and warehousing: meaning, functions, advantages, kinds*, Accountlearning.com. (https://accountlearning.com/storage-warehousing-meaning-functions-advantages-kinds/)

3. *5 types of warehouse storage and their use cases*, Extensiv. (https://www.extensiv.com/blog/warehouse-storage)

WHAT YOU HAVE LEARNT



ANNEXURE I

List of Credits

Lesson 1

Fig. 1.4: Severity of the Bengal Famine (1943); Courtesy: https://t.ly/nOClq

Figure Name: Norman Borlaug; Courtesy: https://t.ly/LxD1q

Figure Name: M.S. Swaminathan; Courtesy: https://t.ly/G3EI7

Figure Name: Verghese Kurien; Courtesy: https://tinyurl.com/3yu2tj8e

Fig. 1.7: Imperial Agricultural Research Institute at Bihar; Courtesy: https://www.iari.res.in/

Fig. 1.8: Indian Agricultural Research Institute, New Delhi; Courtesy: https://www.iari.res.in/

Lesson 4

Fig. 4.2: Tractor-mounted laser land leveller; Courtesy: https://farmech.dac.gov.in

Fig. 4.3: Sprinkler irrigation system; Courtesy: https://shorturl.at/ychjl

Fig. 4.5: Crops cultivation inside a greenhouse; Courtesy: https://shorturl.at/AQDJ4

Fig. 4.7: Application of robotics in agriculture; Courtesy: https://shorturl.at/GDA8v

Fig. 4.8: Vegetation monitoring using satellite imagery; Courtesy: Google Earth

Fig. 4.12: Spraying of pesticide through drones; Courtesy: https://shorturl.at/Ddxwn

Lesson 5

Fig. 5.1: Components of soil; Courtesy: https://rb.gy/ifr147

Fig. 5.3: Textural triangle; Courtesy: https://rb.gy/mpy1ba

Lesson 6

Fig. 6.1: *Sesbania* green manuring in field; Courtesy: Dr. Dinesh Kumar, IARI, New Delhi

Fig. 6.2: Intercropping of Coconut with Marigold; Courtesy: https://rb.gy/63ytom

Fig. 6.4: Chisel Plough; Courtesy: https://shorturl.at/XPTeQ

Fig. 6.5: Rotavator; Courtesy: https://rb.gy/kr9v6f

Fig. 6.7: Earthing up in potato; Courtesy: https://pxhere.com/en/photo/776945

Fig. 6.8: Puddling of soil before rice transplanting in field; Courtesy: https://rb.gy/0xx57c

Fig. 6.9: Transplanting of rice in puddled field; Courtesy: Dr. Dinesh Kumar, IARI, New Delhi

Fig. 6.10: Rice nursery by wet method; Courtesy: Dr. Dinesh Kumar, IARI, New Delhi

Fig. 6.11: Paddy transplanter for mechanical transplanting; Courtesy: Dr. Dinesh Kumar, IARI

Lesson 7

Fig. 7.4: Furrow irrigation, Courtesy: https://t.ly/t5uzl

Lesson 8

Fig. 8.2: Leaf mining and boring by chewing insects, Courtesy: https://rb.gy/t9j84d

Fig. 8.3: Sucking of saps from plant tissues by white fly, Courtesy: https://shorturl.at/BodRK

Fig. 8.5: Leaf mosaic, Courtesy: https://shorturl.at/I4qX4

Fig. 8.5: Leaf curling, Courtesy: https://t.ly/3koCI

Lesson 9

Fig. 9.3: Corms; Courtesy: https://bit.ly/49Kk3Lr

Lesson 10

Fig. 10.6: Plastic low tunnel for vegetable cultivation, Courtesy: NCPAH (https://www.ncpahindia.com/low-tunnel)

Lesson 11

Fig. 11.1: Chrysanthemum loose flower, Courtesy: https://shorturl.at/I90tH

Fig. 11.1: Chrysanthemum cut flower, Courtesy: https://bit.ly/4fB7rrc

Notes

Fig. 11.3: Candytuft, Courtesy: https://bit.ly/41LkYJF

Fig. 11.4: A rose garden lawn, Courtesy: https://rb.gy/yv1l15

Fig. 11.5: Bonsai, Courtesy: https://bit.ly/41IKIpN

Fig. 11.6: Terrarium, Courtesy: https://rb.gy/6d8bk5

Lesson 13

Fig. 13.5: Puffed rice; Courtesy: https://shorturl.at/Gj7lW

Fig. 13.6: Flaked rice; Courtesy: https://tinyurl.com/yu68e46p

Lesson 14

Fig. 14.4: Interior of a warehouse, Courtesy: https://tinyurl.com/mt2c98ez

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FOOD PROCESSING SECTOR: OPPORTUNITIES AND CHALLENGES

Food is one of the basic requirements for our survival. It provides essential nutrients like proteins, carbohydrates, fats, minerals and vitamins, which are necessary for our growth. Raw food materials like grains, fruits and vegetables, milk and fish are produced through cultivation of field crops, horticulture, animal husbandry and aquaculture, respectively. While some of these can be consumed in their natural (raw) form, most of them require processing to become edible. Thus, food processing transforms raw food items into more acceptable, consumable, durable and commercially viable food products like wheat flour, jam, ketchup, pasteurized milk, frozen fish, etc. Food processing has emerged as one of the priority areas of commercial importance in India. It plays an important role not only in reducing food wastage but also developing value-added products. In this lesson, we shall explore the status, scope, challenges, and opportunities in the food processing sector in our country.

LEARNING OUTCOMES

After studying this lesson, the learner:

- defines food processing and explains its importance;
- describes the current status of the food processing sector in our country;
- lists various sub-sectors of the food processing industry;
- discusses the scope and opportunities available in the food processing sector;
- highlights the challenges and constraints faced by the food processing sector; and

- outlines various schemes and initiatives by the government to support the food processing industry.

15.1 IMPORTANCE OF FOOD

Let us start with definition of food. We know that food is something we can eat. It is defined as material, usually of plant or animal origin that contains essential body nutrients such as proteins, fats, carbohydrates, vitamins and minerals for nourishment. The related terms are defined as:

Food Science: It is the discipline that deals with the study of physical, chemical, and biological nature of food, the causes of their spoilage, and the principles of food processing. Its important sub disciplines are food chemistry, food microbiology, food processing, food engineering and food safety and quality.

Food Technology: It deals with the application of food science to the selection, preservation, processing, packaging, distribution and use of safe food.

Food Preservation: This involves treatments given to food to prevent spoilage and deterioration while preserving nutritional value. Examples include drying, addition of salt, sugar, etc. The main objective is to prevent the growth of microorganisms and reduce water activity.

Food Processing: It defied as the treatments given to raw food materials to convert them into edible, less perishable and value-added products. Examples are milling, pasteurization, fermentation, etc.

Post-Harvest Management: It includes handling, cleaning, storing, grading and transportation operations undertaken after the harvest of agricultural commodities.

All raw food materials are processed to improve their taste, nutritional value and shelf life. Foods are processed for the following reasons:

a. Preservation for later consumption or sale to fetch better prices

b. Removal of inedible portions

c. Destruction or removal of harmful substances

d. Conversion into forms desired by the consumers

Food processing industries help in

a. Reducing post-harvest losses and wastes as well as using by-products more efficiently.

Notes

b. Increasing farmers' income by enabling them to obtain better prices and enhancing consumer welfare by increasing the availability of agricultural goods.

c. Maintaining reasonable prices of food produce even during excess production (glut) situations.

The Food Processing Industry (FPI) provides a strong linkage between the two pillars of the economy i.e., agriculture and industry. Food processing plays a crucial role in increasing shelf life, value addition, employment opportunities, farmer's income, export earnings, and reducing wastage of food and food products. This is evident from the following significant factors:

a. Employment generation: Being a direct linkage between agriculture and manufacturing, it provides wide direct and indirect employment opportunities.

b. Increasing farmers' income: With the increase in demand for agri-based products, the price paid directly to farmers increases, thereby increasing their income.

c. Reduction in malnutrition: Fortification of processed foods with vitamins and minerals helps in reducing the malnutrition in the population.

d. Reduction in food wastage: Proper processing of food reduces wastage, resulting in better price realisation for farmers.

e. Boosting trade and earning foreign exchange: Processed food is an important source of foreign exchange. For example, Indian Basmati rice is in high demand in Middle Eastern countries.

f. Control of food inflation: Food processing increases the shelf life of food products and keeps supply in alignment with demand, thus controlling food inflation.

g. Nutrient preservation and spoilage prevention: Proper processing of food preserves the nutritive quality of food and extends shelf life by preventing spoilage due to action of microbes and other agents.

h. Enhancing the food experience: Processing improves the quality and taste of food, offering more choices in the food basket.

i. Enhances consumer choices: Food processing allows food from other parts of the world to be transported to local markets and vice versa.

Notes

INTEXT QUESTIONS 15.1

1. Name five important nutrients present in food.
2. Define food processing.
3. FPI stands for…………..

ACTIVITY 15.1

Collect ten processed food products along with their raw materials.

....

....

....

15.2 PRESENT STATUS OF INDIAN FOOD PROCESSING INDUSTRY

We know that our country is the largest producer of milk, pulses, and spices in the world. We rank second in the production of fruits, vegetables, tea, farmed fish, cotton, sugarcane, wheat, rice, and sugar. Similarly, we stand third in egg production. The Indian food processing industry accounts for 32% of the country's total food market, ranking fifth globally in terms of production, consumption, export and expected growth. The sector has been growing at an average annual growth rate of around 11.18 %. It contributes approximately 8.80% and 8.36% to the gross value addition (GVA) in the manufacturing and agriculture sectors, respectively.

Despite having a substantial production base, the level of food processing in India remains low (<10%). Approximately 8% marine products, 35% of milk, and 6% of poultry are processed. Although India is the second largest producer of fruits and vegetables in the world after China, only about 2% of the total produce is processed. This is due to the lack of adequate processing infrastructure and techniques, which poses a significant challenge to the sector.

The food industry is divided into four major segments; (a) Agriculture Production; (b) Manufacturing / Processing; (c) Distribution; and (d) Marketing.

Notes

Food processing industry in India can be categorized as follows:

- Cereal/ pulse milling
- Milk & milk products
- Meat & meat products
- Fruit & vegetable processing
- Beverages like coffee, tea & cocoa
- Bread, biscuits & other bakery products
- Aerated waters/soft drinks
- Edible oil/fats
- Fish, poultry & egg products
- Beer/alcoholic beverages
- Confectioneries
- Breakfast cereals, malt protein, weaning, extruded food products

The categorization of food processing operations includes primary processing, secondary processing, and tertiary processing. Primary processing (Fig. 15.1) pertains to the transformation of raw agricultural produce, milk, meat, and fish into commodities that are suitable for human consumption. This phase involves a series of activities such as cleaning, grading, sorting, packing, etc.

Fig. 15.1: Primary processing of carrots

Notes

Secondary (Fig. 15.2) and tertiary processing industries usually involve a higher level of processing, where new or modified food products are manufactured.

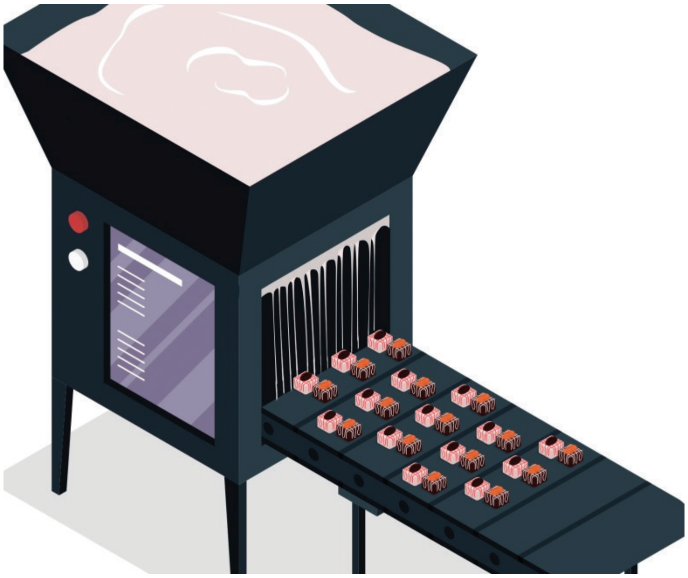


Fig. 15.2: Secondary processing of cakes

Most of the processing operations in India can be classified as primary processing, which results in lower value-addition compared to secondary processing. To boost farmer income and enhance exports, there is a need to improve the value chain in processed food products. Currently, India's agricultural exports primarily consist of raw materials that are processed in other countries, highlighting the potential for India to move up the value chain.

The term 'food processing industries' covers a wide range of relatively modern food processing sectors such as dairy, confectionery, marine products, horticultural and vegetable products, as well as meat and poultry products.

- The cereals sector (wheat, rice, maize, millets) belongs to the first category of processing. Improving efficiency in this sector would lead to higher recovery of desired products and create a number of potentially useful by-products, some of which are not being fully utilized at present.
- The next category is the processing of milk and milk products. This extends the scope of linking the farmers in rural areas to markets, thereby increasing their income.
- The third category relates to processing activities that extend the storage life of seasonal food products such as fruits and vegetables.

To meet the current demand for food materials, the industrial food processing sector has emerged. The food processing sector in the country is mainly handled by the unorganized sector, which contributes approximately 42% of the output. The organized sector accounts for 25% with the remainder coming from small-scale players. The small-scale food processing sector is a significant source of employment.

However, the small-scale food processing sector faces increasing competition from large manufacturers in terms of presentation and marketing. Good packaging is an area of vital importance for small and medium-sized food manufacturers. Food processing has the potential to maintain a safe and continuous food supply for millions of people, including those living in remote and difficult localities. Improvements in processing efficiency, by increasing the yield of unstable products, are one of the important means of reducing food losses and increasing the food supply. The demand for convenience in food preparation at homes, institutions, and restaurants has created a need for food processing industries to provide food ingredients as well as new food forms.

INTEXT QUESTIONS 15.2

1. Food processing industry in India ranks..........................in terms of production, consumption and export.

2. GVA stands for...

3. The ....sector belongs to the first category of processing.

15.3 SCOPE OF FOOD PROCESSING SECTOR

The food processing industries has an enormous potential to boost India's Economy.

- India has a considerable raw material base in the agricultural sector, which provides ample opportunities for the processing sector, which can, in turn create employment. It also has the potential to enhance India's presence in the global export market of food items. Hence increased government intervention and policies are crucial to implement measures that facilitate the growth and development of this industry.

- Estimates suggest that India's current food processing industry is estimated at USD 130 billion and is expected to attract huge domestic and foreign investment.

Notes

- India ranks first in the world in the production of milk, ghee, ginger, bananas, guavas, papayas, and mangoes. Additionally, India ranks second in the world in the production of rice, wheat, and several other vegetables and fruits. Surplus production of cereals, fruits, vegetables, milk, fish, meat, and poultry can be processed and marketed both domestically and internationally, presenting immense opportunities for growth in the sector.
- Due to rapid urbanization, food habits are shifting towards value-added foods.
- India is among the fastest growing economies in the world and has substantial market potential to attract foreign investment in the food processing sector.
- Estimates indicate that around 35% of total food production is wasted due to inadequate facilities for transportation, storage, processing, and marketing. This shows the significant scope for the development of food processing sector.
- In India, the food sector has emerged as a high-growth and high-profit sector due to its potential for value addition, particularly within the food processing industry.
- The food processing industry indirectly employs millions of people in India. The demand for healthy, modern food products is increasing, particularly due to the rising number of working women and nuclear families in urban areas. Thus, the food value chain creates multiple opportunities for investment and employment in storage infrastructure, farming, retail, and quality control.
- The agricultural sector provides employment opportunities for farmers, and self-employment opportunities are available in this sector particularly for women. However, infrastructural facilities like storage and processing centres, transportation networks, and research and innovation for value addition to the product are also crucial.
- The Government of India has launched the SAMPADA scheme to boost the food processing industry in the country. Thus, policymakers have identified food processing as a key sector for encouraging labour movement from agriculture to manufacturing.

INTEXT QUESTIONS 15.3

1. What is the primary objective of the SAMPADA scheme launched by the Government of India?

2. The Indian food processing industry accounts for ....% of the country's total food market.

3. It contributes around ……….. and ………….. % of Gross Value Added (GVA) in Manufacturing and Agriculture, respectively.

4. Around .... percentage (%) of total food production is wasted due to lack of processing facilities.

Notes

15.4 CHALLENGES IN FOOD PROCESSING SECTORS

The food processing industry accounts for one third of the total food market in India. According to a report by Agricultural and Processed Food Products Export Development Authority (APEDA), the food processing industry accounts for 32% of India's food market. However, the growth of the food processing industry faces several challenges:

a. **Lack of availability of raw materials:** Continuous supply of quality raw materials for the processing industry is a challenge in India because of predominance of small and medium-sized farm holdings. These farmers face challenges to access crop inputs and technical advice.

b. **Lack of infrastructure:** Many small-scale food processing industries suffer from inadequate food storage infrastructure, which affects the storage of raw materials. This limitation makes it difficult to transport food items efficiently.

c. **Lack of adequate connectivity:** Some rural production sites are poorly connected to storage or processing facilities. The goods produced in these areas take a long time to reach the food processing units. There is a need to improve connectivity through roads, railways, rivers and airways in these areas.

d. **Old processes:** The foods are often inspected manually. Upgrading technologies is essential to stay competitive in the global market.

e. **Ignorance and human error:** Many food items are wasted daily due to carelessness in handling during shifting, packaging, storing, and transporting. Efficient measures are needed to reduce such waste.

Notes

f. **Excess use of fertilizers and pesticides:** Excessive use of fertilizers, pesticides and other chemicals raises concerns about food quality. Such type of processed foods may not be nutritionally balanced and may pose health risks, especially for children, unless fortified.

g. **Inadequate value addition in processing:** Despite being one of the major producers of agri-commodities, India's level of food processing and value addition remains low, affecting competitiveness and income of farmers.

h. **Limited ability to control quality and safety:** The food value chain involves many people, making it challenging to enforce food quality and safety standards effectively.

i. **Low consumer awareness:** Customers are often unaware of nutritional, food safety, and quality issues. It is imperative to address and prioritize these concerns.

j. **Uncertain climatic conditions:** Adverse weather conditions often cause crop losses for farmers every year, resulting in a limited supply of raw materials for the food processing industry.

k. **Lack of technology:** Advanced technology adoption in food processing industry is still needed to make it more efficient.

l. **Food standards:** Every nation has its food standards for consumable food items and thus, the food processing industries must meet national food standards. Adequate laboratories and technical manpower are required to ensure compliance with these standards.

m. **Perishable commodities:** Perishable items like meat, fish, fruits and vegetables, in particular, have high wastage rates. Minimizing losses in the perishable segment requires significant investment in infrastructure and expansion of processing capacities.

n. **Marketing of processed food**: It is a major problem faced by food processors, particularly micro and small processors. Limited scale of operations affects their ability to invest in marketing and branding, impacting performance of the sector.

o. **Coordination**: Several research institutes are currently engaged in research and development activities aimed at improving and developing products, processes, and technologies. Such efforts are crucial to implement a coordinated effort to disseminate research findings to the industry.

p. **GHP & GMP**: Insufficient emphasis is given to food safety measures along the food value chain. Promoting the implementation of Good Hygiene Practice (GHP) and Good Manufacturing Practice (GMP) is necessary to maintain the standards of food quality. There are other areas such as food testing, quality certification and safety issues that require priority attention and improvement.

Notes

Challenges Faced at the Consumer Level

- Lack of awareness
- Lack of standardization
- Poor quality in processed foods
- Conventional food and eating habits

Challenges Faced at the Farm Level

- Conventional farming techniques
- Lack of modernized farm equipments
- Heavy reliance on rain-fed farming methods
- Low farm produce yield
- Improper grading and sorting
- Inadequate cold storage facilities
- Inadequate handling and transportation facilities
- Inferior quality of food produce
- High advertising costs

Challenges Faced at the Distribution Level

- Insufficient infrastructural support
- Expensive packaging costs for products
- High cost of modern transportation facilities
- Limited market support
- High expenses for cold chain facilities
- Inadequate modern transportation facilities and high costs

Challenges Faced by Food Processing Industries

- Financing
- Higher import duties
- Higher cost of raw material and packaging
- Improper transportation and inadequate cold storage facilities
- Lack of availability of refrigerated containers
- Higher advertising costs
- Limited domestic market

INTEXT QUESTIONS 15.4

1. The food processing industry accounts for .... of the total food market in India.

2. APEDA stands for..

3. GHP stands for...

4. GMP stands for..

15.5 OPPURTUNITIES IN FOOD PROCESSING SECTOR

The Ministry of Food Processing Industries (MOFPI) has launched various schemes to boost the food processing sector. Some of the major initiatives taken by the Government of India to improve the food processing sector in India are as follows:

a) MOFPI launched the **National Mission on Food Processing** in April 2012, sponsored by the central government. The main aim of this scheme was to establish more food processing industries in India and to monitor and supervise the existing ones.

b) The **Mega Food Park Scheme** of the Government of India could be game-changing as it directly connects farmers with industries via mega food parks. It aims to promote the development of modern food processing infrastructure in India.

c) The government is focusing on developing **Agri Export Zones (AEZs).** Under this scheme, many cities such as Ahmedabad, Anand, Vadodara, etc. have been converted into Agri-export zones. These zones foster healthy competition both abroad and in the domestic market.

d) Several NGOs are providing connectivity between producers, food processing units, and the market.

e) The government has introduced several certificate courses related to food processing to increase the skilled manpower.

f) The government is encouraging start-ups and entrepreneurship in the food processing sector.

g) The **Food Safety and Standards Authority of India (FSSAI)** is strengthening the food testing infrastructure of India by upgrading 59 existing food testing laboratories and setting up 62 mobile food testing labs.

h) **Indian Council for Fertilizer and Nutrient Research (ICFNR)** is working on improving research facilities in the fertilizer sector to enhance the quantity and quality of agricultural produce.

i) **Pradhan Mantri Kisan Sampada Yojana (PMKSY):** Launched in August 2017, this scheme consolidates various ongoing schemes like mega food parks, integrated cold chains, and food safety and quality assurance infrastructure. It aims to boost agriculture, modernize food processing operations, and reduce agro-wastage.

j) The Ministry of Food Processing Industries announced the **Human Resource Development (HRD)** scheme in the food processing sector. This scheme is being implemented through State Governments under the National Mission on Food Processing and includes the following components:

- Creation of infrastructure facilities for degree/diploma courses in food processing sector
- Entrepreneurship Development Programme (EDP)
- Food Processing Training Centres (FPTC)
- Training at recognised institutions at State/National level

Notes

k) **Scheme of cold chain, value addition and preservation infrastructure:** The purpose of this scheme is to provide integrated cold chain and preservation infrastructure facilities, without any break, from the farm gate to the consumer.

l) **Make in India:** As part of the "Make in India" campaign, the food processing sector was identified as one of the 25 focus areas. Allowing 100% foreign direct investment (FDI) through automatic route into this sector is a significant step in this direction.

m) **Production Linked Incentive (PLI) Scheme for Food Processing Industry (PLISFPI):** The objective of this scheme is to promote Indian brands of food products, increase employment opportunities for off-farm jobs, and ensure higher income for farmers. The Government announced this scheme in the year 2021 with an outlay of ₹10,900 crore. This aims to create 2.5 lakh jobs by 2026-27, boost exports, and expand food processing capacity to generate processed food output worth ₹33,494 crore.

n) **Pradhan Mantri Formalization of Micro Food Processing Enterprises Scheme (PMFME scheme):** This scheme aims to build the capacity of entrepreneurs through technical knowledge and skill training; improve existing micro food processing enterprises through technology upgradation; integrate them with organized supply chains by strengthening branding and marketing. It is an All India Centrally Sponsored Scheme with an outlay of ₹ 10,000 crores for 200,000 enterprises over 5 years from 2020-21 to 2024-25. It will adopt a One District One Product (ODOP) approach to get benefit of scale in terms of procurement of inputs, availing common services and marketing of products. There may be multiple clusters for one product in a district.

o) Government established **National Institute of Food Technology Entrepreneurship and Management** (**NIFTEM**), **Kundli in Haryana in 2012**. *It* is a higher education institute operating under the Ministry of Food Processing Industries and has been granted the Institute of National Importance status in 2021.

INTEXT QUESTIONS 15.5

1. MOFPI stands for...
2. National Mission on Food Processing scheme was launched in the year ......

3. AEZs stands for...

4. Pradhan Mantri Kisan Sampada Yojana was launched in the year ....

5. PMFME scheme stands for..

6. PLISFPI stands for..

WHAT YOU HAVE LEARNT

- Raw food materials undergo a transformation into edible products through various processing techniques that results in value addition. The operations involved in food processing can be broadly categorized into primary processing and secondary processing.
- All the raw food materials are processed to improve their taste, nutritional value and shelf life.
- Indian food processing industry is one of the largest and ranks fifth in terms of production, consumption and export.
- Most processing in India can be classified as primary processing, which has lower value-addition compared to secondary processing.
- India is currently the largest milk producer in the world, contributing 23% of global milk production.
- India ranks second in fruit and vegetable production in the world, after China.
- The Ministry of Food Processing Industries (MOFPI) has launched various schemes to boost the food processing sector.

TERMINAL QUESTIONS

1. Differentiate primary processing from secondary and tertiary processing.
2. What is the importance of food processing?
3. How does FPI act as a strong linkage between the two pillars of the economy?
4. Explain the present status of Indian food processing industry.
5. What are the different categories within the Indian food processing industry?

Notes

6. Give the present status of cereals and fruits and vegetable processing sectors in India.

7. Discuss the status of milk processing sector in India.

8. Discuss the scope of Indian food processing sector.

9. What are the challenges faced by Indian food processing industry?

10. What are the various opportunities in food processing sector?

ANSWERS TO INTEXT QUESTIONS

15.1

1. Carbohydrates, proteins, fats, vitamins and minerals.
2. Treatment given to food raw materials to convert them into eatable, less perishable and value-added products.
3. Food processing Industry.

15.2

1. Fifth
2. Gross Value Addition
3. Cereals

15.3

1. To boost the food processing industry and encourage labor movement from agriculture to manufacturing
2. 32
3. 8.80, 8.39
4. 35%

15.4

1. One-third
2. Agricultural and Processed Food Products Exports Development Authority
3. Good Hygiene Practices
4. Good Manufacturing Practices

Notes

15.5

1. Ministry of Food Processing Industries
2. 2012
3. Agri Export Zones
4. 2017
5. Pradhan Mantri Formalisation of Micro Food Processing Enterprises scheme
6. Production-Linked Incentive Scheme for Food Processing Industry

GLOSSARY

Food Processing: Treatment given to raw food materials to convert them into edible, less perishable and value-added products. Examples are milling, pasteurization, fermentation, etc.

Food: Material, usually of plant or animal origin that contains essential body nutrients such as proteins, fats, carbohydrates, vitamins and minerals for nourishment.

Foreign Direct Investment (FDI): When a company/organization based in one country such as India invests their money in another country such as China, it is referred to as foreign direct investment.

Gross Value Added (GVA): GVA is defined as the total value of all goods and services produced within a country. It can be computed for different sectors of economy like agriculture, manufacturing, mining, etc.

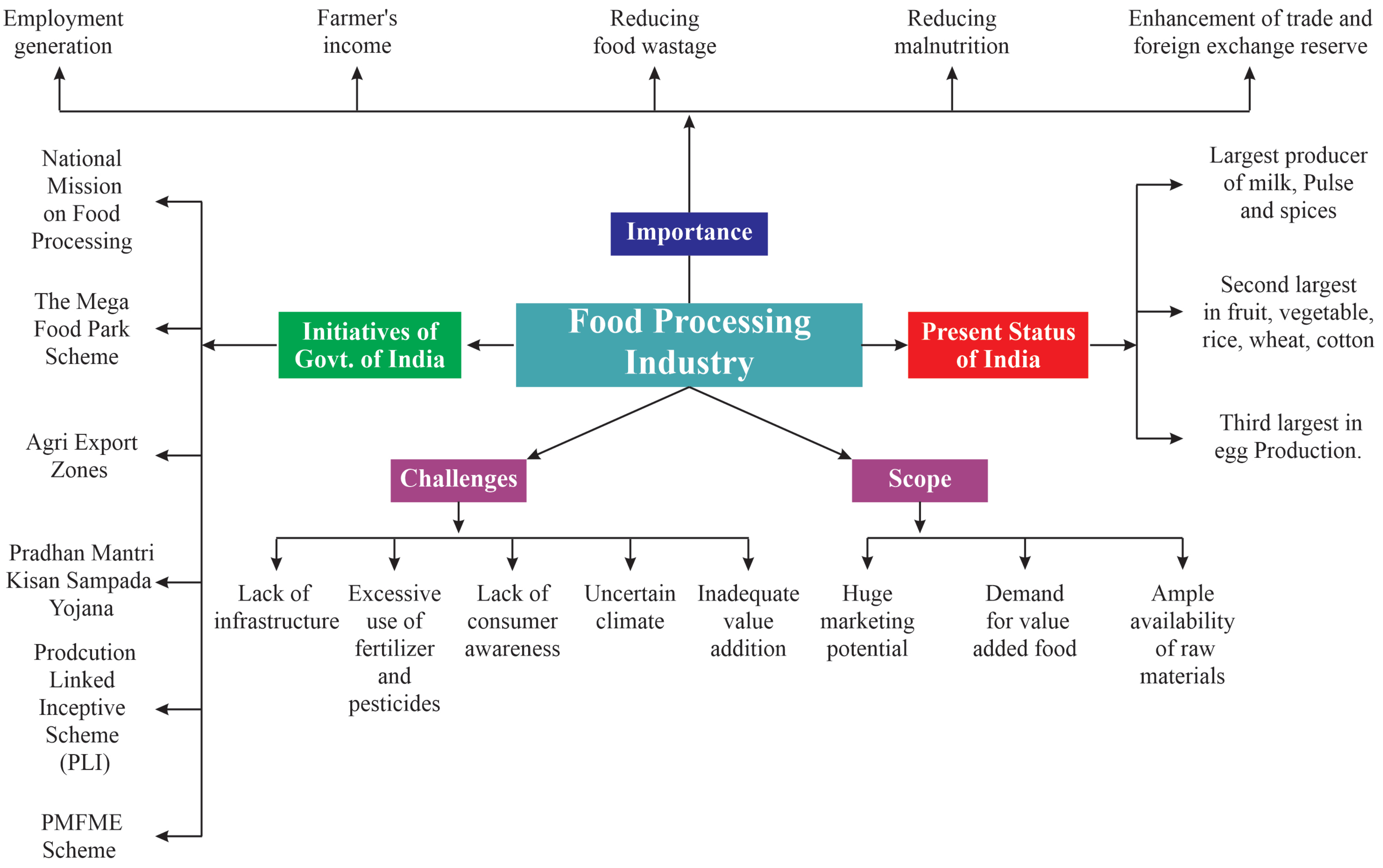
Value Addition: It is the process of transforming original products into a more valuable form, which has higher economic value in the market. For example, production of jam or jelly from fruits, conversion of wheat into *atta* or *maida*.

SUGGESTED READINGS

1. Khader, V. (2013). *Textbook of Food Science and Technology*, Indian Council of Agricultural Research, New Delhi.

2. Srilakshmi, B. (2018). *Food Science*, New Age International Publishers.

WHAT YOU HAVE LEARNT



16

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FOOD GROUPS AND NUTRITIONAL IMPORTANCE

We know that food is the substance which provides us the nutrients necessary for our growth and maintenance. The major sources of almost all foods are either plant or animal in origin. All food comes from plants as even animals depend on plants for their food. We obtain food from plants directly or indirectly, and some food products, like mushroom and spirulina, come from microorganisms. Foods are classified into different food groups, based on characteristics like nutrition, functionality, and stability. The objective is to provide nutritious and balanced food to human beings of all age groups through proper and careful selection of the food constituents. The six essential constituents required by our body are carbohydrates, proteins, fats, vitamin, minerals, and water. Proper amounts of these nutrients are needed to maintain health. In this module, we will learn about the various sources of food, different food groups, and the nutritional importance of food constituents.

LEARNING OUTCOMES

After studying this lesson, the learner:

- states the different sources of food;
- classifies food into various food groups;
- explains the importance of a balanced diet;
- lists the nutrients present in food;
- describes the importance of nutrients in our food; and
- identifies important food sources for these nutrients.

Notes

16.1 SOURCES OF FOOD

The sources of food are broadly classified into two groups: plants and animals, along with their related products.

16.1.1 Plants as A Source of Food

Many plants or plant parts are eaten as food. There are around 2,000 plant species which are cultivated for food. The plant parts which are eaten are called edible parts and these include roots, stems, leaves, flowers, seeds and fruits.

Plants provide us with vegetables, coffee, cereals, pulses, fruits, sugar, oil, etc.

- Vegetables are a type of plant matter that is commonly eaten as food. Some nutrient-rich vegetables include beetroot, spinach, cauliflower, etc. Roots, leaves, and stem of some plants are edible and consumed as vegetables.
  - Radish, carrot, turnip and beetroot are some of the edible roots that are consumed as vegetables.
  - Potato and ginger are the examples of modified stems eaten as vegetables.
  - Spinach, cabbage, lettuce are the examples of edible leaves.
  - Broccoli and cauliflower are the flowers eaten in the form of vegetables.
  - Fruits are a healthy source of food from plants. They are the ripened ovaries of plants, including the seeds within. Orange, mango, apple, grapes, etc. are some of the fruits consumed by humans.
- Cereals include rice, wheat, maize, jowar, barley, etc. These are rich sources of carbohydrates provided by the plants.
- Coffee and tea are widely grown in the southern and north-eastern parts of India and are obtained from plants.
- Sugar is processed from the sugarcane plant.
- Oil can be extracted from the seeds and leaves of the plants such as castor, mustard, and sunflower.
- Spices like cinnamon, cardamom, pepper, clove, cumin seeds, and ginger are obtained from the plants.

16.1.2 Animals as A Source of Food

Animals are used as food either directly or indirectly through the products they produce. These include milk and milk products, eggs, meat and honey. These products are rich sources of nutrients.

- **Milk:** It is obtained from cows, buffaloes, sheep, goat, and camels. Milk is also called as an ideal food as it is rich in vitamins, minerals, proteins, carbohydrates and fats. Dairy products made from milk include paneer, cheese, butter, ghee and curd.
- **Eggs:** Chickens, ducks, geese, and quails are raised for eggs and meat. Eggs are rich source of protein and vitamins, phosphorus, calcium and iron. Poultry products are also rich in proteins.
- **Meat:** Meat is an example of direct product obtained from an animal, which comes from muscle systems or organs. It can be categorized into red meat (from cows, goats, sheep, and pigs) and white meat (from chicken and fish). White meat contains less fat and is easier to digest compared to red meat. Meat is rich in proteins, vitamins, zinc, phosphorus and iron.
- **Honey:** It is a sweet liquid produced by honeybees from the nectar (sweet juice produced by flowers). It contains sugar, water, minerals, and enzymes.

INTEXT QUESTIONS 16.1

1. Name the different plant parts from which food is obtained.
2. Foods that share similar nutritional properties are put together in specific food groups (True/False).
3. The root crop which is eaten as vegetable:

   a. Potato　　b. Carrot

   c. Cauliflower　　d. Brinjal
4. Give example of two dairy products.
5. The meat which has a lot of fat is called ....

Notes

16.2 BASIC FOOD GROUPS

16.2.1 Classification on Type of Food

Foods that humans eat come from either plant or animal sources and are primarily categorized as vegetarian and non-vegetarian. Foods are grouped into specific categories because they provide similar amount of key nutrients. To meet nutrient requirements essential for good health, it is important to consume a variety of foods from each of the five food groups daily, in appropriate amounts.

Enjoying a variety of foods within each group is crucial because different foods vary in the amount of the nutrients that they provide. Knowledge of food groups is essential for meal planning. Foods with similar nutritional properties are grouped together based on the classification of ICMR (Indian Council of Medical Research) (Fig 16.1), which is described as follows.

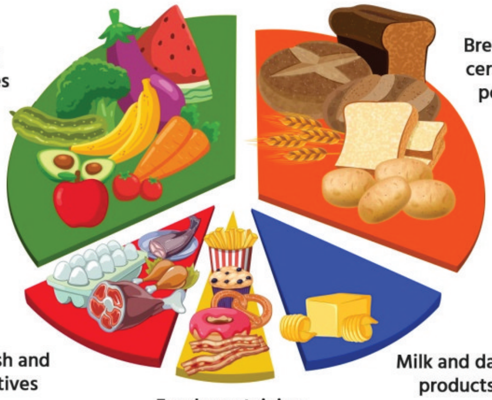


Fig. 16.1: Different Food Groups

A. Cereal Grains and Products

Cereal grains are rich in carbohydrates, fibre, and some vitamins and minerals. These foods act as fuel for our body by providing energy. Examples of this food group are wheat, rice, maize (Fig. 16.2), bajra, rice flakes, wheat flour, sprouted cereals etc. Whole grains are the healthiest choices among this food group. Examples of whole-grain foods include whole wheat bread, oatmeal, whole-grain crackers and breakfast cereals, whole wheat pasta, barley, brown rice, etc.

Notes

Fig. 16.2: Maize

B. Pulses and Legumes

Pulses and legumes are rich in fibre, protein, energy, some vitamins and minerals, and are naturally very low in fat. Examples include beans, chickpea (Fig. 16.3), lentil, black gram, green gram, red gram, bengal gram, soybean, etc.

Fig. 16.3: Chickpeas

C. Milk and Meat Products

This food group is rich in protein, fat and some vitamins (like Vitamin B_{12}) and minerals (such as Calcium). Important examples are milk, cream, cheese and yoghurt, which are excellent sources of protein and calcium. In addition, dairy products are also high in vitamins A, B and D. The foods in this group are important for maintaining healthy bones. Meat products are important sources of iron, zinc, protein and vitamin B. Eggs are high in protein and iron. Fish is an excellent source of protein, while meat is rich in Vitamin B_{12}.

Notes

D. Fruits and Vegetables

Vegetables such as cabbage, spinach, cauliflower, broccoli and carrots as well as fruits like mangoes, oranges, lemons, grapes, peaches and apricots are rich in essential nutrients that your body needs.

These foods provide many vitamins and minerals in addition to fibre and important enzymes. In addition, these foods are low in fats and sugars. They help in preventing diseases, promoting digestive health and boosting the immune system.

E. Fats and Sugars

Foods that contain fats and sugars, such as cheese, butter, salad dressing and oil are powerful energy sources, as they are high in calories. A **Calorie** is the amount of heat needed to raise the temperature of a gram of water by one degree Celsius.

Likewise, sweets, such as jams, jellies (Fig. 16.4), desserts, candy, syrup and soft drinks, are incredibly high in sugar. These foods are often termed empty foods as they lack essential vitamins and minerals and should be consumed in moderation.

Unsaturated fats from sources like seeds, vegetable oil, nuts, fish, olive oil and avocados are beneficial because of their cholesterol lowering properties.

Fig. 16.4: Jam (left) and jelly (right)

ACTIVITY 16.1

Provide a list of five fruits, vegetables, and cereals that you consume on a daily basis.

....

....

....

16.2.2 Functional Classification of Foods

A. Energy-giving Foods

This group includes foods rich in carbohydrates and fats. Cereals, roots and tubers, dried fruits, sugar and fats form important energy-giving foods.

B. Body-building Foods

The foods rich in protein are called body-building foods. These may be broadly divided into two groups:

- Milk, egg, meat and fish – foods rich in proteins of high biological value
- Pulses, oil seeds, nuts and low-fat oilseed meals - foods rich in proteins with medium nutritive value

Biological value of food is calculated as the percentage of protein intake actually utilized in the body.

C. Protective Foods

Foods rich in proteins, vitamins and minerals are termed as protective foods. These are broadly classified into two groups:

- Foods rich in vitamins, minerals and proteins having high biological value e.g., milk, eggs, fish and liver
- Foods rich in specific vitamins and minerals, e.g., green leafy vegetables and some fruits.

ACTIVITY 16.2

Collect small amounts of various food items. Group them according to their sources or the parts of plants from where they are obtained.

....

....

....

16.2.3 Classification Based on pH of The Food

The acidity of food is expressed in terms of pH and it has great influence on distribution of microorganism. Different foods have different pH and lower the pH, greater the ease of processing or sterilization. Foods are categorized into four categories on the basis of pH, which are described as follows:

A. Low Acid Foods

These foods have pH above 5. Examples include peas, corn, meat, fish, milk, poultry, eggs, etc.

B. Medium Acid Foods

These foods have pH between 4.5 and 5. Examples include soups, sauces, pumpkin, spinach, asparagus, etc.

C. Acid Foods

These foods have pH in between 3.7 and 4.5. For example, tomato, pineapple, pear, etc.

D. High Acid Foods

Foods having pH 3.7 or lower are known as high acid foods. Examples include citrus juices, pickles, jam, jellies, berries, etc.

16.2.4 Classification Based on Shelf Life

Foods can be classified into three groups based on how long they can be kept without any treatment. The term 'perishable' refers to food items that have a short shelf life and are susceptible to spoilage.

A. Perishable Foods

These foods deteriorate (spoil) quickly unless special methods are used to prevent spoilage. These foods cannot be stored for more than one or two days at room temperature. Milk, meat, fish, poultry are good examples of perishable food. The rate of spoilage depends upon temperature and moisture content of the product.

B. Semi-perishable foods

They have less moisture content and a longer shelf life than perishable foods.

These foods can be stored for a couple of weeks to even a month or two without any detectable signs of spoilage. Examples are cereal and pulse products like wheat flour, semolina, and certain fruits and vegetables like citrus fruits, aonla, apples, roots and tubers, potatoes, onions, garlic, etc.

C. Non-perishable Foods

These can be kept for months or years without spoiling, provided they are handled and stored properly. They have very low moisture content and are not easily susceptible to spoilage by microorganisms and enzymes. Examples of non-perishable foods include cereals, pulses and nuts, oil seeds, fats and oils, honey, sugar, jaggery, salt, and some spices.

INTEXT QUESTIONS 16.2

1. Give any four examples of perishable foods.
2. pH of low acid foodsis

a. Above 4.5	b. Below 2.5
c. Above 6.5	d. Below 1.5

3. Which foods are known as body building fruits?
4. Citrus is a high acid food (True/False).
5. Foods rich in ……………., ……………….. and ……………… are known as protective foods.

16.3 BALANCED DIET

A balanced diet is essential for maintaining a healthy body and mind. No single food can provide all the essential nutrients that the body needs to stay healthy and function efficiently. A balanced diet should include the right amounts of protein, fats, carbohydrates,fibre, vitamins, minerals, and fresh drinking water. This balance comes from consuming a variety of fresh vegetables, fruits, whole grains, and lean protein sources.

An inadequate supply of essential nutrients can result in

- Poor growth and development

- Poor physical and mental health
- Increased susceptibility to infections
- Higher risk of disease
- In extreme cases, death also

Therefore, consuming foods in proportion to their nutritional value helps in preventing infections, disorders and diseases.

The term **"Optimum Nutrition"** can be defined as eating the right amount of nutrients on a proper schedule to achieve the best performance and the longest possible lifetime with good health.

Notes

ACTIVITY 16.3

Record your diet for a day. Evaluate each meal in terms of inclusion of the five food groups. Do you think that your diet is balanced? Justify your answer with reasons.

....

....

....

The **food pyramid** (Fig. 16.5) is a graphic depiction of the daily food guide. The size of each section in food pyramid represents the recommended number of servings per day. The broad base at the bottom emphasizes that grains should be consumed in abundance and serve as the foundation of a healthy diet. Fruits and vegetables are positioned at the next level, indicating that while they play a vital role in nutrition, their intake should be moderate. Meat and dairy products appear in a smaller band width near the top, highlighting that although they provide essential nutrients like proteins, vitamins and minerals, they should be eaten in limited quantities to avoid excessive fat and cholesterol intake. Fats, oils and sweets occupy the tiny space, indicating that they should be consumed sparingly.

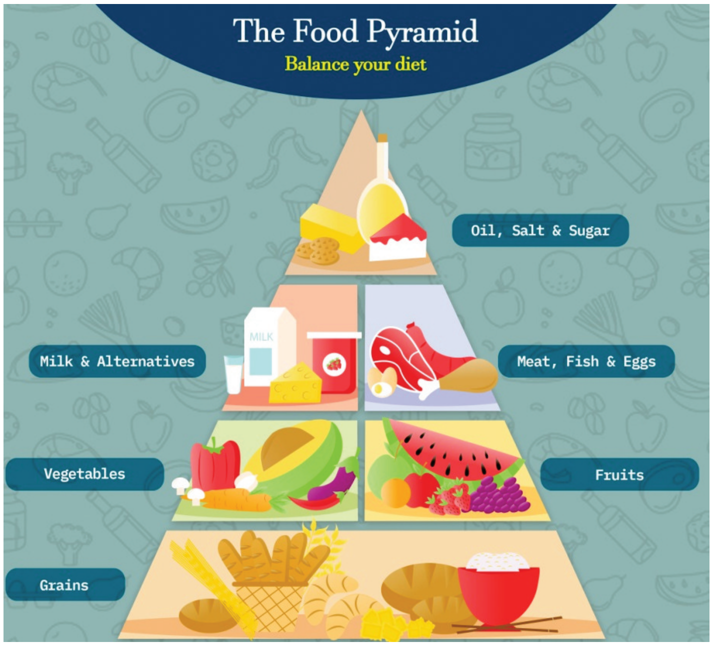


Fig. 16.5: Food Pyramid

Notes

ACTIVITY 16.4

List 10 foods that you commonly eat. Identify the food group to which each food belongs. Then, list the macronutrients and micronutrients present in each of the listed foods. Identify the foods which are the richest sources of energy.

....

....

....

INTEXT QUESTIONS 16.3

1. Define optimum nutrition.

   ....

   ....

2. What do you mean by balanced diet?

   ....

   ....

3. Enlist some of the disorders that result from an inadequate supply of essential nutrients.

....

....

16.4 NUTRIENTS PRESENT IN FOOD

Food is a complex substance composed of chemical constituents called nutrients. These nutrients are required for the proper functioning of cells, tissues and different organs in all living organisms. These constituents give foods their structure, texture, colour, flavour and nutritive value. Since our body cannot synthesize these nutrients on its own; these need to be supplied through external sources, such as food. The six general kinds of nutrients are carbohydrates, fats, proteins, vitamins, minerals and water. These nutrients are broadly classified into two categories: Macronutrients and Micronutrients.

The nutrients that are essential for the body in lesser amounts are known as micronutrients, whereas the nutrients that are required by the body in greater amounts are known as macro-nutrients.

A. Carbohydrates

Carbohydrates are naturally occurring sugars, starches and fibres found in fruits, grains, vegetables and milk products. They constitute the major part of our diet and are the primary source of energy. Carbohydrates are composed of sugar molecules, and about 70% of the energy required for all our body functions is obtained from them. The recommended minimum intake of carbohydrates is 100 g/day to ensure proper fat metabolism. Carbohydrates provide 4 calories of energy per gram.

Functions of carbohydrates

- Carbohydrates provide fuel for the central nervous system and energy for muscles.
- They also prevent protein from being used as an energy source and enable fat metabolism.
- They play an important role in proper functioning of the brain.

Sources of carbohydrate

The main sources of carbohydrates in the diet are starch, sugar and fibre. The sources of starch are mainly cereal grains (wheat, rice, etc.) or tubers (potatoes, sweet potatoes, cassava, etc.). Starches include bread, cereal, and pasta. They also include certain vegetables, like potatoes, peas, and corn. The sources of sugar are sugarcane and fruits. Fibre is found in many foods that come from plants, including fruits, vegetables, nuts, seeds, beans, and whole grains.

B. Proteins

Protein is one of the principal nutrients along with carbohydrates, fat, vitamins, minerals, and water. It is one of the most abundant components in the body. Proteins provide 4 calories of energy per gram and are essential for life. There is no life without protein. Protein is contained in every part of your body, the skin, muscles, hair, blood, organs, eyes, fingernails, and even bones. Next to water, protein is the most abundant substance in our body.

Proteins occurring in animal and plant tissues are called **native proteins**. Proteins are composed of the smaller units called amino acids, which are referred as the building blocks of protein. There are about 20 different amino acids which are commonly known.

Amino acids consist of carbon, hydrogen, oxygen, nitrogen, and, in some cases, sulfur. The body cannot synthesize or produce nine of the amino acids, so they must be obtained through food. These are known as essential amino acids namely histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Eggs are a good source of all essential amino acids in appropriate quantities.

Functions and requirement

Protein is primarily used in the body to build, maintain, and repair body tissues. The amount of protein needed varies depending upon age, body size, and growth stage. Different stages of growth, including infancy, childhood and pregnancy, increase the protein need to provide building materials. Physiological states such as injury, surgery, or burns, increase the need for protein to provide repairing materials.

Notes

Sources

Protein is available from both animal and plant sources. The animal foods like eggs, milk, meat (white and red) and fish contribute to animal protein sources. Whereas, examples of plant sources of proteins are cereals, millets, legumes, nuts, seeds and green leafy vegetables.

C. Fat

Fat is a major source of energy and helps our body to absorb vitamins. It is also important for proper growth, maintaining healthy skin, and promoting proper eyesight and brain development in children. Fats, also called lipids, are insoluble in water but soluble in organic (i.e., non-polar) solvents like chloroform, benzene, ether, etc.

The insolubility of lipids in water, in several cases, is due to the presence of one or more fatty acids in them. Dietary fat is divided into two types: saturated (solid at room temperature) and unsaturated (liquid at room temperature).

Essential fatty acids (EFAs) are the ones that cannot be synthesized within the human body, and therefore must be obtained from the diet. Our body is incapable of producing the EFAs, like linoleic acid and alpha-linolenic acid and therefore, must be obtained from food. Therefore, you must remember that '**Every fat is a lipid but every lipid is not fat'**.

Functions of fat:

- Fats supply energy and heat to the body (9 calories of energy per gram).
- Fats are the most concentrated source of energy as it produces twice the energy than carbohydrates.
- Fat is necessary for maintaining healthy skin, and it plays a central role in promoting proper eyesight and brain development in children.
- Fat supplies essential fatty acids (EFAs).
- Vitamins A, D, E, and K are fat-soluble vitamins which transport fat into and around the body.

Sources

Saturated fats are sourced primarily from animal products like red meat, lard, butter, poultry with skin and whole milk dairy products. Vegetable oils like palm

Notes

and coconut are also some of the examples of saturated fats. Unsaturated fats are found primarily in vegetable oil sourced from plants like peanut, canola, sunflower, corn, etc.

D. Vitamins

Vitamins are low molecular weight organic (carbon containing) substances needed for normal function, growth and maintenance of good health. The vitamins may be soluble in water or fat. Water-soluble vitamins dissolve in water while fat-soluble vitamins are absorbed and transported by fat.

Water soluble vitamins are vitamin C (Ascorbic acid) and B complex group. The water-soluble vitamins are carried in bloodstream and are not stored in the body. Vitamin B complex is group of several compounds that are essential for normal cell functioning. Vitamin B complex contains: Thiamine (B_1), Riboflavin (B_2), Folic acid (Folacin) (B_9), Niacin (B_3), Pantothenic acid (B_5), Biotin (B_7), Cyanocobalamin (B_{12}) and Pyridoxine (B_6)

Excess amounts of these vitamins may cause extra work on kidneys. Fat soluble vitamins are vitamins A (Retinol), D (Calciferol), E (*a*-Tocopherol) and K (Phylloquinone, menaquinones). Vitamin A and D in excess can be harmful; however vitamin E and K are usually not associated with toxicity.

The functions, sources and diseases caused due to deficiency of various water- and fat-soluble vitamins are presented in Table 16.1 as given below.

Table 16.1 Functions, sources and deficiency diseases of various water- and fat-soluble vitamins

S. No	Vitamin	Functions	Deficiency diseases	Sources
1.	Vitamin A (Retinol)	• Vision • Immune system • Healthy skin • Bone and tooth growth	Night Blindness	Meat, milk, fish, cheese, cream, butter etc.

Notes

S. No	Vitamin	Functions	Deficiency diseases	Sources
2.	Vitamin C (Ascorbic acid)	• Maintain healthy bones, skin, and teeth • Healing of wounds and fractures	Scurvy	Aonla, citrus fruits, oranges, sweet lime, grapefruit, berries, guava, capsicum and green leafy vegetables
3.	Vitamin D (Calciferol)	• Needed for proper absorption of calciumand phosphorus • Promotes the development of bones and teeth	Rickets (bones become soft)	Egg yolks, liver, fatty fish, fortified milk, fish liver oils, etc.
4.	Vitamin E (Tocopherol)	• Acts as antioxidant • Protects cell walls	Nerve and muscle damage that affects movement and coordination, vision problems, weakened immune system	Wheat germ oil, oils from cereal seeds, salad oils, fruits, nuts, and vegetables etc.
5.	Vitamin K (Phylloq-uinone)	• Needed for synthesis of prothrombin, which functions in blood clotting	Excess bleeding and lower bone density	Green leafy vegetables, especially spinach, cabbage etc.
6.	Vitamin B_1 (Thiamine)	• Needed for energy metabolism • Important for nerve function	Beriberi	Cereal grain (particularly wheat) germ layers, pulses (peas, beans), nuts, poultry, egg yolk and fish etc.

Notes

S. No	Vitamin	Functions	Deficiency diseases	Sources
7.	Vitamin B_2 (Riboflavin)	• Energy metabolism • Building tissues • Maintain good vision	Slow growth, sore eyes	Dairy products, lean meats, poultry, fish, grains, broccoli, spinach etc.
8.	Vitamin B_3 (Niacin)	• Needed for energy metabolism, proper digestion, and healthy nervous system	Pellagra	Lean meat, fish, poultry, groundnuts, pulses and whole grain cereals
9.	Vitamin B_5 (Pantothenic acid)	• Needed for oxidation of carbohydrates and fats	Acne and paresthesia	Whole grain cereals, pulses etc.
10.	Vitamin B_6 (Pyridoxine)	• Needed for protein metabolism • Helps to make red blood cells.	Pink eye and neurological symptoms (epilepsy)	Meat, especially liver, some vegetables and grain cereals with bran
11.	Vitamin B_7 (Biotin)	• Required for the metabolism of proteins and carbohydrates • For production of hormones and cholesterol	Reduced development and nervous syndromes in children	Liver, kidney, egg yolk, groundnuts and some vegetables etc.
12.	Vitamin B_{12} (Cobalamin or Cyano-cobalamin)	• Essential for the metabolism of carbohydrates	Loss of memory	Milk, muscle meat, cheese, eggs and sea foods, liver and kidney

Notes

S. No	Vitamin	Functions	Deficiency diseases	Sources
13.	Folic acid (Folacin)	• Prevents birth defects that damage the brain and spinal cord	Lack in expectant females may cause delivery faults, mainly neural tube defects.	Yeast, kidney, liver and green leafy vegetables, especially spinach, asparagus and broccoli, dried beans, whole wheat bread etc.

E. Minerals

The minerals are inorganic components of food that leave ash as residue when burnt. They make up about 5% of the body weight and play crucial roles as catalysts in many biological reactions within the body. Their other functions include building of bones and other structural parts of the body, facilitation of muscular contraction, transmission of messages through the nervous system, and assist in the digestion and utilization of nutrients.

The human body requires about 20 mineral elements. Each has a specific function and they can be found in a wide variety of foods. Unlike vitamins, minerals cannot be destroyed by heat. Depending upon their amounts in the adult body, the minerals are classified as macronutrients and micronutrients. The macronutrients are present in the amounts greater than 0.005% of the body weight, while the micronutrients are present in less than 0.005% of body weight.

The macro minerals are required in the adult human diet at levels higher than100 mg/day. Micro minerals (also known as trace elements) are required in the amounts less than 20 mg/day. The functions and sources of various macro and micro minerals are presented in Table 16.2 as given below.

Table 16.2 Functions and sources of various macro and micro minerals

S. No	Minerals	Functions	Sources
1.	Calcium	• Healthy bones, teeth and immune system	Blackberries, dates, milk, egg, pomegranate, almonds, wheat, soybeans etc.

2.	Sodium	• Helps in the regulation of blood pressure • Proper functioning of nerves and muscles	Onions, fresh fruits, sweet potato, broccoli, pumpkin seeds, eggs, milk etc.
3.	Iodine	• Promotes healthy hair, nails, skin and teeth • Controls body weight and growth	Sea foods, iodized salt, milk and foods that are grown in iodine-rich places
4.	Phosphorus	• Formation of bones, teeth etc.	Pomegranate, dates, beef, tuna, oats etc.
5.	Flourine	• Healthy teeth • Prevents dental caries • Strengthen bones	Drinking water
6.	Magnesium	• Production and transport of energy • Important for the contraction and relaxation of muscles	Milk, dairy products, legumes, nuts, and leafy green vegetables
7.	\Potassium	• Maintain intercellular osmotic pressure • Regulate pH • Promotes metabolism	Fruits and vegetables, dried peas, dairy products, meats, and nuts
8.	Sulphur	• Essential part of various amino acids, thiamine, insulin, biotin	Meats, milk, eggs, and legumes
9.	Chlorine	• Maintain the osmotic pressure of extracellular fluids, regulates pH, and maintains electrolyte balance.	Onions, fresh fruits, sweet potato, broccoli, pumpkin seeds, eggs, milk etc.

10.	Iron	• Catalyzes the formation of Vitamin A	Liver, meat products dried apricots, raisins, whole-grain cereals, legumes, and molasses
11.	Molybdenum	• Necessary for the metabolism of sulfur-containing amino acids, such as cysteine	Legumes such as lentils, beans and peas
12.	Manganese	• Necessary for healthy bone structure • Component of several enzyme systems	Nuts, legumes, whole-grain cereals, leafy green vegetables and fruits
13.	Copper	• Normal functioning of muscles, nervous system and immune system • Required for normal growth and health	Vegetables, legumes, beans, nuts and legume seeds, mushrooms, avocado and whole grain cereals
14.	Selenium	• Acts as an antioxidant that works with vitamin E	Poultry, meats, fish, and nuts
15.	Cobalt	• Component of cyanocobalamin (Vitamin B_{12}) • Needed for the synthesis of several enzymes	Liver, lean meats, and milk
16.	Chromium	• Essential for the use of carbohydrates • In the absence of chromium, there is disturbed glucose mechanism in the body	Liver, lean meats, spices and wine

D. Water

Water, a most essential nutrient, is second only to oxygen in importance for the body. It serves as an ideal medium for transporting dissolved nutrients throughout the body and excretion of wastes. Water is a component of every cell, tissue, and organ, accounting for about 60% of body weight.

In addition to drinking water, some foods contain a high percentage of water. Apart from this, oxidation of carbohydrates, fats and proteins in the body also produces water.

Functions of water

- It is the chief component of all body fluids.
- It helps in
  - a) Muscle contractions
  - b) Nutrient transport
  - c) Regulation of body temperature
  - d) Excretion of waste products
- It helps in digestion.
- It is a source of dissolved minerals such as fluorine and calcium.
- It keeps the body fluids liquid, so that they may flow easily.

INTEXT QUESTIONS 16.4

1. Mention the general kinds of nutrients required for our health.

   ....

   ....

2. The substances that protect body cells and the immune system from damage by harmful chemicals in air and foods are called ....

3. The required minimum amount of carbohydrates is ....g/day to ensure efficient oxidation of fat.

4. Proteins occurring in animal and plant tissues are called ....

5. Lipids are insoluble in ....and soluble in ....

6. Give examples of any three essential amino acids.

   ....

WHAT YOU HAVE LEARNT

- Foods that share similar nutritional properties are grouped together in specific food groups.
- Perishable is a term which is used for the food that spoils within a very short period of time.
- A balanced diet should contain the right amounts of protein, fats, carbohydrates and fibre, which can be obtained from fresh vegetables and fruits. This ensures a good supply of essential amino acids, essential fatty acids, vitamins, minerals, and fresh drinking water.
- Foods are complex substances composed of chemical constituents called nutrients. The six general kinds of nutrients are carbohydrates, fats, proteins, vitamins, minerals and water.
- Amino acids are made up of the elements carbon, hydrogen, oxygen and nitrogen, with the exception of sulphur in some amino acids.
- Water, a most essential nutrient, is second only to oxygen in importance for the body.
- Vitamins can be either water-soluble or fat-soluble. Water-soluble vitamins dissolve in water and are carried in the bloodstream; and are not stored in the body; excess amounts are eliminated with waste products. Fat-soluble vitamins are absorbed and transported by fat; excess amounts are stored by the body for later use.
- Every fat is a lipid, but not every lipid is a fat.

TERMINAL QUESTIONS

1. Define an essential nutrient.
2. List some common sources of carbohydrates.

3. Explain how fats provide energy.
4. List some common sources of protein.
5. Distinguish between essential and non-essential amino acids.
6. Define a calorie.
7. Discuss the general characteristics of fat-soluble vitamins.
8. List the fat-soluble vitamins and describe the major functions of each vitamin.
9. Explain what is meant by the vitamin B complex.
10. Describe the major functions of water-soluble vitamins.
11. Discuss the general characteristics of minerals.
12. List the major minerals and describe the major functions of each mineral.
13. List some good sources for each of the major minerals.
14. Define a balanced diet.
15. Why are vitamins and minerals called micronutrients?
16. Compare water-soluble and fat-soluble vitamins.
17. Why is folate a very important vitamin?
18. What can occur due to vitamin A deficiency?
19. Why are sodium, chloride, and potassium called electrolyte minerals?
20. Why is fluoride needed in the diet?
21. Explain the Food pyramid.

ANSWERS TO INTEXT QUESTIONS

16.1

1. Roots, stems, leaves, flowers, seeds and fruits
2. True
3. Carrot (option b)

4. Paneer and curd
5. Red meat

16.2

1. Milk, meat, fish, poultry
2. Above 4.5 (option a)
3. The foods that are rich in protein are known as body building foods.
4. True
5. Proteins, vitamins and minerals

16.3

1. Optimum nutrition can be defined as eating the right amounts of nutrients on a proper schedule to achieve the best performance and the longest possible lifetime in good health.
2. Failure to flourish, poor growth and development, poor physical and mental health, infections or even death.
3. A balanced diet contains protein, fats, carbohydrates and fibre in the form of fresh vegetables and fresh fruit, all in the right amounts, providing a good supply of essential amino acids, essential fatty acids, vitamins, minerals, and of course fresh drinking water.

16.4

1. Carbohydrates, fats, proteins, vitamins, minerals and water
2. Antioxidants
3. 100
4. Native proteins
5. Water, organic solvents
6. Histidine, leucine and lysine

GLOSSARY

Body building food: Such foods are rich in protein. Milk, egg, meat fish, pulses come under this group.

Energy giving food: Foods rich in carbohydrates and fats are referred to as energy giving foods. Examples include cereals, roots, tubers, and dried fruits.

Food pyramid: It is a graphic representation of daily food guide. The size of each section in the food pyramid represents the number of daily servings of each type of food that a person should eat.

Non-perishable foods: These foods can be stored for months or years without spoiling. Examples include are cereals, pulses, nuts, jaggery etc.

Perishable foods: These are foods which deteriorate (spoil) quickly and they cannot be stored for more than one or two days at room temperature. Milk, meat, fish, fruits and vegetables are good examples of perishable food.

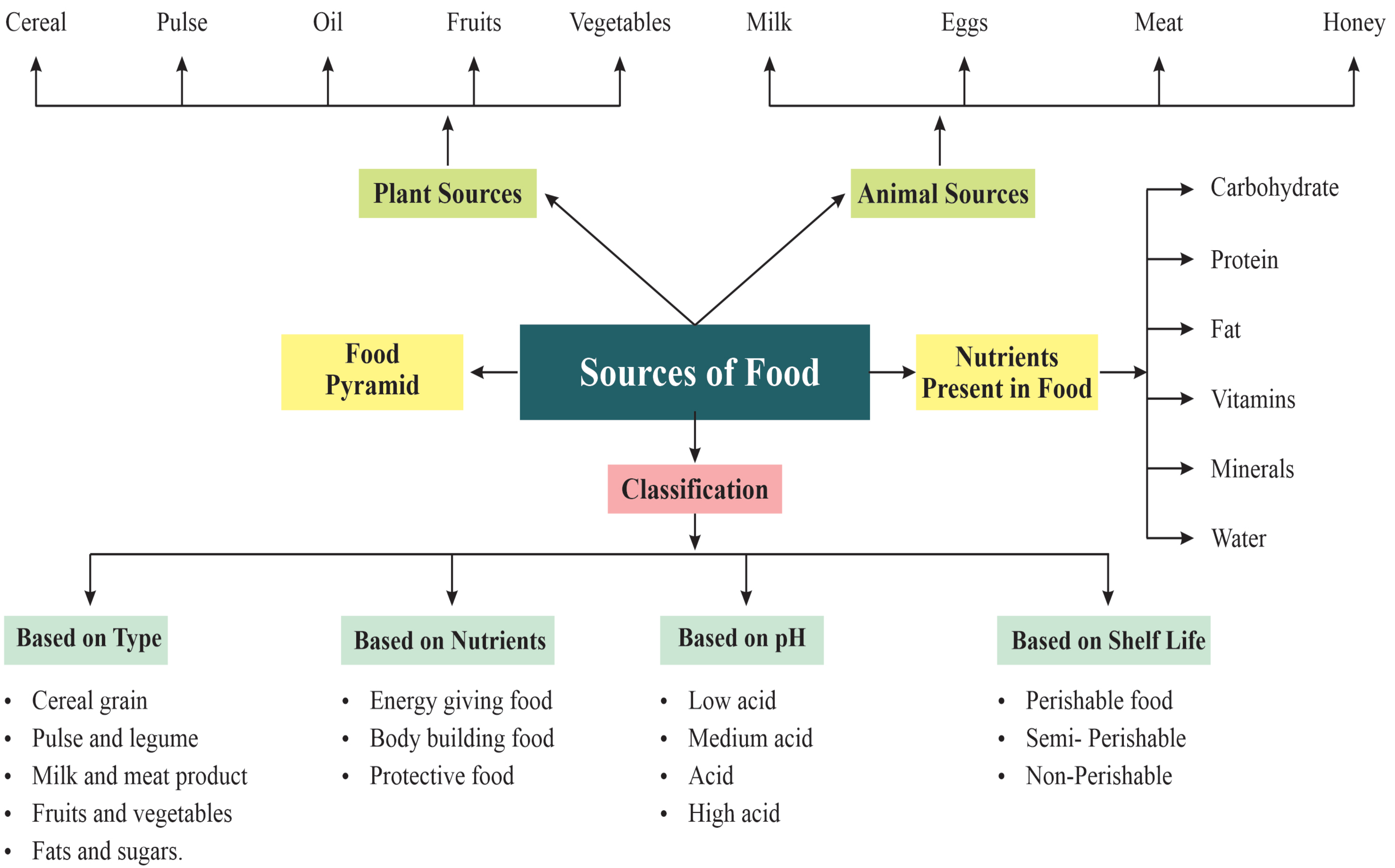
Protective food: Foods rich in proteins, vitamins and minerals are termed as protective foods. E.g., green leafy vegetables, fish liver.

SUGGESTED READINGS

1. *Fundamentals of Food Technology*, B.Sc. (Horticulture), e-Krishi Shiksha, Agricultural Education Division, Indian Council of Agricultural Research, New Delhi (https://ecourses.icar.gov.in/).

2. Khader, V. (2013). *Textbook of Food Science and Technology*, Indian Council of Agricultural Research (ICAR) Publication, New Delhi.

WHAT YOU HAVE LEARNT



17

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TYPES AND METHODS OF FOOD PROCESSING

In this lesson, we will learn about the transformation of raw food materials into safe, nutritious, and stable food products on the journey from farm to fork. In the first two lessons, we covered the basics of food science and the importance of a balanced diet. This lesson will explain the processing operations involved in making our ready-to-eat food products, including fruit juice, pasteurized milk, UHT flavored milk, noodles, canned fruits, and various other processed food products. The food processing industry is evolving to meet market demands, with automated operations enhancing safety, productivity, and cost-effectiveness.

Food is a living entity and can spoil easily, affecting human health. Today's consumers are health-conscious and seek safe, convenient, and nutritious food. This lesson covers the principles of important traditional methods like thermal processing, food dehydration, cooling and freezing, as well as emerging technologies such as high hydrostatic pressure and pulse electric field, etc.

LEARNING OUTCOMES

After studying this lesson, the learner:

- recognizes the common food spoilage factors;
- explains the principle of food preservation;
- describes different levels and important methods of food processing;
- lists the advantages and disadvantages of different processing techniques; and
- enlists the emerging techniques in food processing.

17.1 TYPES OF FOOD PROCESSING

Food processing is the process of transforming agricultural products into food, or converting one form of food into another. It involves various physical and chemical techniques to convert raw materials into edible food products. Food processing can be classified into three categories: primary, secondary, and tertiary.

Primary Food Processing

Primary food processing involves basic cleaning, grading, and packaging of horticultural items such as fruits and vegetables. For example, processing cereal grains to produce flour.

Secondary Food Processing

Secondary food processing uses primary processed products and further processes them into prepared-to-eat meals. It includes the alteration of the basic product to a stage just before final preparation. For instance, milling of paddy to rice or using cereal flour to make the batter for bread.

Tertiary Food Processing

Tertiary processing involves the production of high value-added ready-to-eat foods such as bakery products, instant foods, pizzas, health drinks, and more.

INTEXT QUESTIONS 17.1

1. Differentiate primary processing from secondary processing.

   ....

   ....

2. Utilizing cereal flour to make batter is an example of .... processing.

17.2 PRINCIPLES OF FOOD PRESERVATION

Food Spoilage

When food items are kept for a long period of time and not stored properly, they get spoiled. Once the food is spoiled, it cannot be eaten and has to be thrown away. Spoilage is a process in which food items deteriorate to the point where it is not safe for human consumption. The different causes of food spoilage are discussed as follows:

Notes

Causes of Food Spoilage

- Growth and activities of microorganisms, principally bacteria, yeasts, and molds. For example, mold growth on bread.
- Activities of food enzymes lead to changes such as browning in apples, potatoes, etc.
- Infestation by insects, parasites, and rodents. For example, spoilage of food products in a field or warehouse.
- Chemical changes in food cause browning of fruits and vegetables.
- Physical changes or damages such as those caused by freezing (freezer burn), drying (caking), etc.
- Contamination with chemical agents. For example, chemical contamination by using too much detergent or sanitizer to clean food preparation surfaces.
- Presence of air. For example, spoilage of fat and oil-based foods.
- The temperature at which the food is stored. For example, spoilage of meat and milk when stored at improper temperatures.
- The gaseous atmosphere surrounding the food. For example: spoilage of canned foods.
- The relative humidity of the atmosphere surrounding the food. For example, spoilage of cereal and bakery products.
- The pH of the food and its ability to resist pH change. For example, spoilage of fermented foods.
- High water activity of the food supports microbial growth in all food products.
- Moisture content. For example, when a coffee pouch is opened, it starts absorbing moisture which can lead to caking.

ACTIVITY 17.1

Collect different food products from your day-to-day life that have spoiled and specify the causes of spoilage.

....

....

....

Principles of Food Preservation

To combat spoilage of foods, various preservation methods are used in food industries based on the following principles:

a) **Prevention or delay of microbial decomposition of food**

- By keeping out micro-organisms (asepsis)
- By removal of micro-organisms (filtration)
- By hindering the growth or activity of micro-organisms (use of low temperature, drying, creating anaerobic conditions or chemicals)
- By killing the micro-organisms (using heat or irradiation)

b) **Prevention or delay of self-decomposition of food**

- By destruction or inactivation of food enzymes (blanching or boiling)
- By prevention or delay of chemical reactions (use of antioxidants to prevent oxidation)

c) **Prevention of damage by external factors** such as insects, animals, mechanical causes etc. (use of fumigants, packaging etc.).

INTEXT QUESTIONS 17.2

1. The main cause of browning of apples is……………………………………..
2. ………………………….. is the method of inactivating food enzymes.
3. …………………….. is the main cause of spoilage of coffee.

17.3 METHODS OF FOOD PROCESSING

Thermal Processing

Thermal processing is a food sterilization technique in which the food is heated at a temperature high enough to destroy microbes and enzymes. There are two main temperature categories employed in thermal processing: Pasteurization and Sterilization. There are a number of types of heat processing methods employed in the food industry that are discussed as follows:

A. Blanching

It is a pretreatment process applied to foods, particularly fruits and vegetables, using mild heat for a specific time followed by rapid cooling or transferring immediately to the next processing stage. The time and temperature combination varies from product to product, the conditions, and size of the product. Generally, the temperature varies from 88-99^{o} C. The primary purpose of blanching is to destroy enzymes that cause spoilage and deterioration in fruit and vegetables. While blanching is not used as a sole method of preservation, it serves as an important pretreatment step before freezing, drying, and canning.

Functions of blanching

- To preserve the natural color
- To eliminate air from the product
- To destroy undesirable enzymes
- To avoid damage to the product
- Reducing surface microbial contamination.

Methods of blanching

- **Hot water blanching:** In this method, vegetables are immersed under pre-warmed water (70 to 100 °C) for varying amount of time, depending on type and quantity.
- **Steam blanching:** In steam blanching, the food product is carried on a belt through a steam chamber into which live steam is constantly injected.

Advantages

- Smaller loss of water-soluble components

- Lower capital cost
- Better energy efficiency

Disadvantages

- There is loss of texture and sensory characteristics.

B. Pasteurization

The process of pasteurization is named after the French chemist and microbiologist Louis Pasteur, who discovered in 1862 that applying heat at temperatures below boiling point could inactivate spoilage organisms in wine. The method was later adapted for milk and has become a critical operation in milk processing.

Pasteurization is a heat-processing method designed to kill pathogenic (disease-causing) organisms and most spoilage organisms. It is a short-term preservation method that extends the storage life of the product while ensuring it has safe bacterial activity. This method is commonly used for pasteurizing milk, as shown in Figure 17.1

Fig. 17.1 Pasteurized milk

Methods of pasteurization

- **HTST (High Temperature Short Time) method:** In this method, raw milk is heated to 72 °C (161 °F) for 15 seconds.
- **LTLT (Low Temperature Long Time) method:** In this method, raw milk is heated to 62.8 °C (145 °F) for 30 minutes.

Notes

- **UHT (Ultra High Temperature) method:** In this method, raw milk is heated to 138 °C (280 °F) (or higher) for 2 seconds.

Advantages

- Less floor space is required
- Easier to clean and sanitize
- Lower operating cost
- It extends shelf life of product for days or weeks
- It reduces the risk of food poisoning

Disadvantages

- There is some nutritional loss
- It kills only pathogenic microorganisms

C. Sterilization

Sterilization is more intensive heat process aimed at destroying all micro-organisms, including both pathogenic and non-pathogenic types. In this process, food products are sealed in containers and exposed to temperatures above 100 °C. Temperatures above 100 °C, usually ranging from 110-121 °C, are used depending on the type of product, and it must be reached inside the product.

Some organisms, such as *Clostridium botulinum* can survive during the sterilization process if the sterilization process is not performed for an adequate time or at sufficiently high enough temperature.

Types of sterilization

- **In package sterilization:** In this method, the food product is packed into containers, which are then sterilized. This process is commonly used in canning.
- **Aseptic or Ultra high temperature (UHT) processing:** In this method, the food product and the package are sterilized separately. Then, sterile product is then filled into the sterile package and sealed under controlled conditions. For instance, tetrapack fruit juices and soups, etc.

Notes

Advantages

- It extends the shelf life of product
- Economic and short processing time

Disadvantages

- There is some nutritional loss, especially of vitamin C and B group vitamins.
- Sometimes affect the appearance and taste of food.
- Microorganisms in their spore forms are difficult to kill.

D. Canning

Canning involves the application of heat to destroy micro-organisms and their spores in food. This process requires that the heat-treated or sterilized food be sealed in an airtight container to prevent contamination. An example of canned food is presented in Figure 17.2.

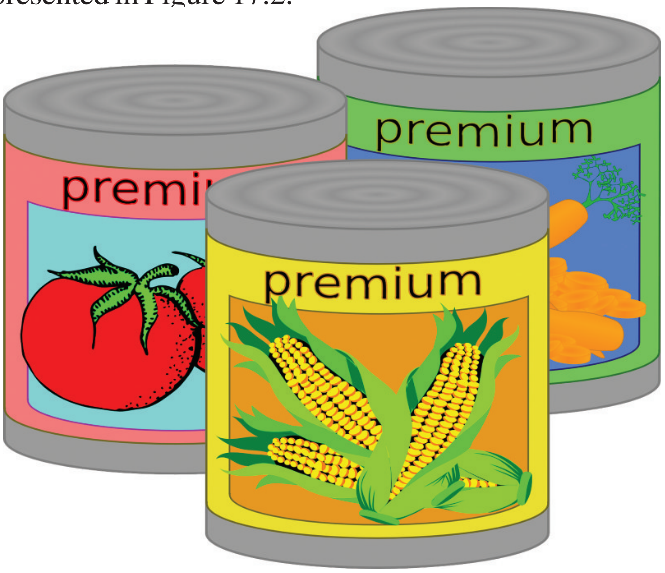

Fig. 17.2: Canned food

Steps of canning

Canning is carried out in following sequential steps:

a) **Washing, peeling, and slicing:** The food is washed, cleaned, and inedible parts such as bones in meat and stones in fruit are removed.

b) **Blanching:** Vegetables are usually blanched either by immersing them in boiling water or exposing them to steam. This step inactivates enzymes and removes air bubbles, reducing its bulk.

c) **Brining (for vegetables) and syruping (for fruits):** The cans are automatically filled with fruits, vegetables and other foods and they are topped up with liquid such as brine (salt water) or syrup to ensure preservation.

d) **Exhausting and sealing:** The filled cans are exposed to steam or hot water to drive out air (exhausting). The cans are then sealed with a lid using an automatic machine, ensuring they are airtight or hermetic.

e) **Heat processing and cooling:** The cans are sterilized (121°C) and then cooled gradually.

Aseptic canning

In aseptic canning, both the food and the container are sterilized separately. The food is then filled into the sterilized container in such a way that prevents contamination from micro-organisms.

Quality of Canned Foods

The sterilization process can cause the loss of heat-sensitive nutrients, such as ascorbic acid (vitamin C) and thiamin (vitamin B_1). Additionally, the process can lead to changes in colour, flavour and texture of the food.

E. Drying/Dehydration

Drying is one of the oldest methods that humans have been using for a long time. The process involves reducing the water or moisture content of the product by natural means, such as solar energy. On the other hand, dehydration is performed artificially, using methods such as fryers to lower the moisture content of food and prevent bacterial growth and spoilage. The primary objective of drying is to extend the shelf life of food products. Methods include heat-based techniques (e.g., vacuum drying, tray drying, heat pump drying, etc.) or cold temperatures based techniques (e.g., freeze-drying). Example of dried food (raisin) is shown in Figure 17.3.

Fig. 17.3 Dried raisin

Notes

Methods of drying/dehydration

a. **Sun Drying:** This method is effective in hot dry climates, however the process is slow, and the foods being dried are vulnerable to contamination.

b. **Tray or cabinet drying:** Hot air flows either through the product or over the product to remove moisture.

c. **Deep bed drying:** Material to be dried is placed in a bin, and hot air is circulated through it.

d. **Fluidized bed-drying:** Warmed air is circulated around the fluidized food particles.

e. **Spray drying:** It is used for liquids. The liquid is sprayed through fine nozzles into a stream of hot air. The water evaporates and leaves behind a fine powder.

f. **Roller or drum drying:** This is suitable for pasted (thick) foods. The paste forms a thin film on the surface of a heated roller or drum, which dries during rotation of the roller (or drum), and is finally removed by scrapers (doctor blade).

g. **Freeze-drying:** This involves an initial freezing process followed by gradual heating in a vacuum cabinet. During this process solids (ice crystals) are directly converted into vapour without going through the liquid stage **(sublimation process).**

Advantages

- Lightweight and easy to transport
- Longer shelf life
- Helps to preserve excess food

Disadvantages

- Alters food structure
- Loss of vitamins A, B_1, C and E
- High-fat content foods prone to rancidity and discoloration
- Taste may differ from fresh food

ACTIVITY 17.2

Collect different food products produced by different methods:

- Spray drying
- Freeze drying

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Notes

F. Freezing

Freezing process extends the shelf life of food products by inhibiting the growth of most of the bacteria. It can be carried out using two methods: mechanical freezing and cryogenic or flash freezing (using liquid nitrogen at -196 ºC). Frozen food (frozen peas) is presented in Figure 17.4.

Freezing controls the growth of micro-organisms in two ways:

a. Water is unavailable for microbial growth because it has been converted to ice.

b. Chemical changes in food are slowed down because of the low temperature.

Fig. 17.4 Frozen peas

Before freezing, inedible parts of the food are removed and the food is subjected to blanching (hot water treatment) to inactivate enzymes.

Notes

Blanching is a mild heat treatment, usually applied to fruits and vegetables before freezing to inactivate enzymes and maintain their quality.

Methods of freezing

a. **Plate-freezing:** In this method, the food is placed between hollow metal plates through which refrigerant is passed, causing the food to freeze.

b. **Blast-freezing:** This involves exposure of the food to a blast of pre-cooled air (- 40 °C) in a specially designed tunnel.

c. **Fluidized bed-freezing:** This is a development of blast-freezing and is suitable for food of small particle size. Suitable foods include peas, beans and soft fruits.

d. **Immersion freezing:** This involves immersing the food in the refrigerant such as Brine (salt water) for fish. However, this method is not widely used.

e. **Cryogenic freezing:** This method uses liquid nitrogen (-196 °C) or carbon dioxide (-78 °C). It is more costly than other methods.

Food Preservation Using Conventional Methods

1. Chemicals

Chemical preservation involves the use of chemical compounds to preserve food. Appropriate quantities of certain chemicals added to the food can hinder the undesirable spoilage in the food by various mechanisms.

Mechanism

- Interfering with the cell membrane of the micro-organisms, their enzyme activity or genetic material
- By acting as an anti-oxidant

The optimum quantity of preservative as per approved regulation need to be used as higher concentrations can pose health risks.

Examples

Chemical preservatives include benzoic acid and its sodium salt, sorbic acid, potassium meta-bisulphite, calcium propionates, etc. Common antioxidants to prevent flavour (rancidity) in edible oils include butyl hydroxy anisole (BHA), butyl hydroxy toluene (BHT), tertiary butyl hydroxy quinone (TBHQ), lecithin,

etc. Addition of organic acids like citric, acetic and lactic acid in the food inhibits the growth of many micro-organisms.

Advantages

- They can keep food fresher for longer period of time
- Extends the shelf-life of foods
- Slow or prevent changes in colour, flavour and texture and delays rancidity

Disadvantages

- Inappropriate dosage of chemical preservatives in foods can pose serious health risks such as cancer, neurological disorders etc.

ACTIVITY 17.3

Collect different foods that are preserved using chemical preservatives by comparing their shelf-life.

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2. Fermentation

Fermentation is a value addition process for food products. It is a method of preserving food by allowing microorganisms to act on the food in a controlled environment. Fermentation process preserves the food by production of acid or alkali, enhancing the flavor, increasing the shelf life, and boosting the marketability of the food product. Various factors such as temperature, type of microbes, oxygen levels, pH etc. influence the fermentation process.

Mechanism

The fermentation process involves the oxidation of carbohydrates to generate a range of products, which are mainly organic acids, alcohol, and carbon dioxide. Such products have a preservative effect and inhibit spoilage by limiting the growth of microorganisms.

Notes

Examples

Examples of fermented foods include cheese, yoghurt, sauerkraut, pickles, idli, dosa, wine, bread etc.

Advantages

- It helps in preserving food nutrients.
- It increases the digestibility of foods.
- It helps to maintain intestinal bacteria.
- It exhibits anti-cancer effect.
- It strengthens the immune system.

Disadvantages

- Production of gas and alcohol which can cause spoilage.
- Over-fermentation may allow the growth of harmful bacteria or mold, which can cause food poisoning or spoilage.
- Fermentation may produce a strong or pungent odor, which some people may find unpleasant or unappetizing.
- Improperly fermented foods can lead to inconsistencies in flavor, texture, and appearance.
- Some individuals may have allergies or intolerances to certain fermented foods or the microbes used in the fermentation process.
- The fermentation process can be time-consuming and require specialized equipment, making it difficult for small-scale producers or individuals to produce fermented foods at home.

3. Salting

Salting is a preservation technique, often used for curing of meat such as bacon. When salt or a salt solution (brine) is applied to food products, it reduces the moisture content and activity of water (a_w) to microorganisms, ultimately inhibiting their growth. This is due to the process of osmosis, which causes the water to pass out of the cell and dehydrate it. With little moisture, the growth of microorganisms is slowed down.

Concentration of salt

Salt acts as preservative when its concentration is increased above 12%. Salt levels between 18 and 25% in solution generally will prevent all microbial growth in foods.

Methods

There are two methods of salting:

- **Dry salting:** Dry salting is used to draw the moisture out of food, which helps to reduce the growth of unwanted bacteria. In this method, salt is directly applied to food products. Example: fish.
- **Brining:** The brine, a flavoured solution of salt, both draws out moisture and permeates the food. In this method, food products are immersed in salt/water solution (brine). Example: fish.

Examples

Pickles, smoked meat, preserved tamarind, raw mango, aonla, fish and meat.

Advantages

- It acts as preservative by inhibiting microbial growth.
- It regulates fermentation by inhibiting the growth of bacteria, yeast and moulds.
- It is an excellent source of sodium, an essential mineral.

Disadvantages

- It increases the sodium content of food.
- High dosage of salt in food results in raising blood pressure.

4. Sugaring

Sugaring is a preservation method used for fruits such as peaches, plums, and pineapple. The fruit pieces are cooked with sugar or dipped in sugar syrup and then sterilized. Sugar is also used in the manufacturing of jam and crystallized fruits.

Notes

Mechanism

The addition of a large quantity of sugar inhibits the growth of microorganisms by making the water in the fruit cells unavailable. Additionally, the moisture available to microorganisms is reduced by osmosis.

Examples

Sugaring is commonly used for fruits, vegetables, pickles, and fermented foods, among others.

Advantages

- It facilitates the production of other substances that act as preservatives, like alcohol and acids. Example: in case of beer, wine etc.
- It increases the shelf-life of foods.
- It creates an environment that limits microbial survival and growth.

Disadvantages

- It increases the sugar content of foods.

Food Preservation Using Other Techniques:

1. MAP

Modified atmosphere packaging (*MAP*) is the method used to extend the shelf life of food by modifying the composition of the gases inside the food packaging. The gases used in MAP are oxygen (O_2), nitrogen (N_2) and carbon dioxide (CO_2). Example of potato wafers packed with N_2 gas is presented in Figure 17.5.

Fig. 17.5 Potato wafers packed with N_2 gas

Mechanism

In this process, the natural ambient air inside the package is replaced by a gas or gas mixture, often nitrogen and carbon dioxide. This packaging under a protective atmosphere preserves the quality of fresh produce over a longer period of time and prolongs shelf-life of foods.

Advantages

- Prolonged shelf life compared to other conventional storage methods
- Improvement in visual appeal of packaged products
- Preservation of food nutrients
- Prolonged preservation of food freshness
- Elimination of chemical additives/preservatives
- Retention of original food flavours

Disadvantages

- Capital cost of machinery is very high
- Benefits of MAP are lost once the package is opened
- High cost of gases and packaging materials

Applications

MAP is widely used in the preservation of foods like meat products, bread, fresh pasta, fish, fruits and vegetables, readymade salads etc.

2. Hurdle Technology

Combining two or more preservation technologies in a single process to destroy microorganisms is known as hurdle technology. This process ensures that food products are safe for consumption and have a good shelf life.

Hurdle technology is used in the food industry for the gentle and effective preservation of foods. In hurdle technology, hurdles are deliberately combined to improve the sensorial and nutritional profile of food products and enhance the microbial stability of foods. Thus, hurdle technology aims to achieve the total quality of foods by applying an intelligent and appropriate mix of hurdles. Examples of hurdles in a food system include low temperature during storage, high temperature during processing, and the presence of preservatives.

Principle

The principle behind hurdle technology is based on the influence of various food preservation methods on the behavior of microorganisms in foods, including their homeostasis, metabolic exhaustion, and stress reactions. For this purpose, the concept of multi-target food preservation plays an important role in achieving effective food preservation.

Advantages

- It avoids the reliance on single preservation method.
- There is greater possibility of using natural preservatives in combination with synthetic ones.
- This helps in getting safe and tasty products of high quality.
- It saves energy, money and several other resources.
- It is suitable for both large- and small-scale industries.

Disadvantages

- This technique could provide varying results depending upon various bacterial stress reactions.

Applications

Hurdle technology has wide applications in preservation of various food products like dairy products, fruits and vegetables, fruit derived products, meat and meat products etc.

INTEXT QUESTIONS 17.3

1. Drying is basically reducing the.................................... in the product.
2. .... drying is used for paste (thick) foods.
3. .... is the principle behind freeze-dried foods.
4. Examples of vitamins lost in the drying process are................... ....
5. The time and temperature combination in High-Temperature Short Time (HTST) pasteurization of milk is ....

17.4 EMERGING NON-THERMAL TECHNOLOGIES

Several non-thermal and emerging technologies are used in food processing and preservation, including hurdle technology, high pressure processing, and ultrasonication. Some of the emerging non-thermal technologies in food processing and preservation are discussed in the chapter. Table 17.1 presents a list of both thermal and non-thermal methods used in food processing and preservation.

Table 17.1 Thermal and non-thermal methods of food processing and preservation

S. No.	Type	Methods
1.	Thermal methods	• Microwave heating • Radio frequency heating • Infrared heating • Ohmic heating • Induction heating
2	Non-thermal methods	• High hydrostatic pressure technology • Cold plasma • Pulsed electric field • High voltage arc discharge • Ultrasonication • Irradiation • Ultraviolet light treatment • High pressure carbon dioxide treatment • Use of natural antimicrobials • Oscillating magnetic field • Use of ozone • Chemical treatment

A. High Pressure Processing (HPP)

High Pressure Processing (HPP) is a cold pasteurization technique by which food products, already sealed in their final package, are placed into a vessel and subjected to a high level of isostatic pressure (300–600 MPa) transmitted by water. The pressure applied is isostatically transmitted inside a pressure vessel. Pressures above 400 MPa inactivate the microorganisms present in food, increasing their shelf life and ensuring food safety.

Notes

Principle

The basic principles of HPP are isostatic and Le Chatelier's principle. The difference in these two principles is summarized in Table 17.2.

Table 17.2: Different principles of high-pressure processing of foods

S. No.	Principle	Mode of action
1.	Isostatic	If a food product contains sufficient moisture, pressure will not damage the product at the macroscopic levels as long as the pressure is applied uniformly in all directions
2.	Le Chatelier's	Any change in phase transition results in decrease in volume which is enhanced by pressure as pressure is inversely proportional to volume

Advantages

- Excellent food quality
- Destroys pathogens and ensures food safety
- Extends product shelf life
- Improves customer satisfaction
- Inactivates microorganisms and enzymes
- Retains quality, such as colour and flavour
- Only requires water and electricity

Disadvantages

- Bacterial spores are not inactivated by pressure alone.
- Most suitable for acid foods

Applications

High-pressure processing has wide applications in meat products, ready-to-eat meals, seafood products, juices and fruit products, dairy products, etc.

B. Ultrasonication

Ultrasonication results in food preservation, food processing, and modification of texture and food analysis. The ultrasonic blades vibrate at high frequencies of 20 kHz, 30 kHz, or 40 kHz.

Principle

High intensity ultrasonic waves cause the formation and collapse of bubbles within liquids, a phenomenon known as cavitation. It is the main principle of ultrasonication. This process leads to various effects, including mechanical disruption and microbial inactivation.

Advantages

- Increased productivity
- Easily adapted into existing production lines

Disadvantages

- Needs more input of energy
- Results in the formation of free radicals that causes changes in food compounds.

Applications

Ultrasonication has its wide applications in meat processing, microbial inactivation, mixing, etc.

C. Pulse Electric Field

Pulsed electric field (PEF) is a non-thermal method of food preservation that uses short pulses of electricity to inactivate micro-organisms while minimally affecting food quality attributes. Pulsed electric field (PEF) is used to preserve food, while high-intensity pulsed electric field (HIPEF) processing involves applying pulses of high voltage (typically 20-80 kV/cm) to foods placed between two electrodes. HIPEF is suitable for preserving liquid and semi-liquid foods, inactivating micro-organisms, and maintaining functional constituents.

Principle

The basic principle of PEF technology is to apply short pulses of high electric fields, with duration of microseconds to milliseconds and intensity in the order of 10-80 kV/cm. The applied high voltage results in an electric field that causes microbial inactivation, with electroporation being the main principle behind the process.

Advantages

- Reduction in micro-organisms
- Shorter treatment time

- Increased shelf-life of foods
- Maintains food safety
- Kills microorganisms while preserving the original color, flavor, texture, and nutritional value of the unprocessed food

Disadvantages

- It does not inactivate enzymes.
- Refrigeration is required for improving the shelf-life of food products.
- It is not suitable for solid food products.

Applications

Applications of PEF include preservation of beverages and semi-liquid food products etc.

INTEXT QUESTIONS 17.4

1. HPP stands for..
2. The pressure range involved in HPP processing of foods is ....
3. The main principle involved in HPP of foods is ....
4. Pulsed electric field (PEF) uses .... pulses to preserve the food
5. .... is the main principle involved in PEF processing of foods.
6. Cavitation is the main principle involved in .... process.

WHAT YOU HAVE LEARNT

- Food processing is a method of converting raw foodstuffs into final, well-cooked consumable products.
- The main aim of food processing is to provide food products of the highest quality.
- Food processing techniques fall into three classifications: primary, secondary, and tertiary.
- Drying is basically the process of reducing the water or moisture content in the product.

- Pasteurization is a processing method that is mainly applied to milk.
- Freezing increases the shelf life of food products and inhibits the growth of most bacterial species.
- Blanching is a mild heat treatment, usually applied to fruits and vegetables, to denature enzymes.
- Foods can be preserved by the application of sufficient heat to kill all microorganisms and inactivate enzymes.
- In hurdle technology, multiple preservation methods are deliberately combined to improve the sensorial and nutritional profiles of food products and enhance the microbial stability of foods.
- High-Pressure Processing (HPP) is a cold pasteurization technique where food products, already sealed in their final package, are introduced into a vessel and subjected to a high level of isostatic pressure.
- PEF uses short pulses of electricity for microbial inactivation.

Notes

TERMINAL QUESTIONS

1. Define food processing.
2. What is the importance of food processing?
3. Compare thermal and non-thermal techniques of food processing.
4. How would you differentiate primary, secondary, and tertiary types of food processing? Please provide examples.
5. What is drying? Why is it done?
6. List various methods of drying used for different foodstuffs.
7. How does freezing control the growth of microorganisms?
8. What is blanching? Why is it done?
9. Differentiate fluidized bed freezing from cryogenic freezing.
10. Differentiate HTST pasteurization from UHT pasteurization.
11. How does the sterilization process affect the quality of foods?
12. What is canning? Explain the different steps of canning.
13. What is hurdle technology? How is it beneficial?

14. What is HPP of foods? Explain its principle.
15. What is the mechanism of HPP of foods?
16. What are the application areas of high-pressure processing of foods?
17. What is PEF processing of foods? What is its importance?
18. Explain the principle of PEF processing of foods.
19. What are the advantages and disadvantages of PEF technology?
20. What is ultrasonication technology? Explain its principle.
21. What are the application areas of ultrasonic techniques in food processing?

ANSWERS TO INTEXT QUESTIONS

17.1

1. Primary food processing is the method of transforming horticultural items into nourishments that can dispose off quickly. On the other hand, secondary food processing is the method of utilizing primary food processed product to make prepared to-eat food meal.
2. Secondary

17.2

1. Action of enzymes
2. Blanching
3. Moisture

17.3

1. Moisture content
2. Drum
3. Sublimation
4. Retinol (vitamin A), thiamin (vitamin B_1), ascorbic acid (vitamin C), and vitamin E
5. 72!/15 seconds

17.4

1. High pressure processing
2. 300–600MPa
3. Le Chatelier's
4. Short electric
5. Electroporation
6. Ultrasonication

GLOSSARY

Fermentation: It is an anaerobic process in which microorganisms release energy from carbohydrates in absence of oxygen.

Food spoilage: It is a process in which food items deteriorate to a point where it becomes unsuitable and unsafe for human consumption. Food spoilage can occur due to physical, chemical and biological changes.

Pasteurization: Pasteurization is a heat-processing method designed to kill only harmful organisms. Here food is heated at temperature below 100°C.

Sterilization: It is a heat processing technique where both harmful and beneficial organisms are killed by exposing the material to temperature above 100°C.

Thermal processing: A food sterilization technique in which the food is heated at a temperature high enough to destroy microbes and enzymes. Pasteurization and sterilization are the commonly employed techniques for thermal processing of foods.

SUGGESTED READINGS

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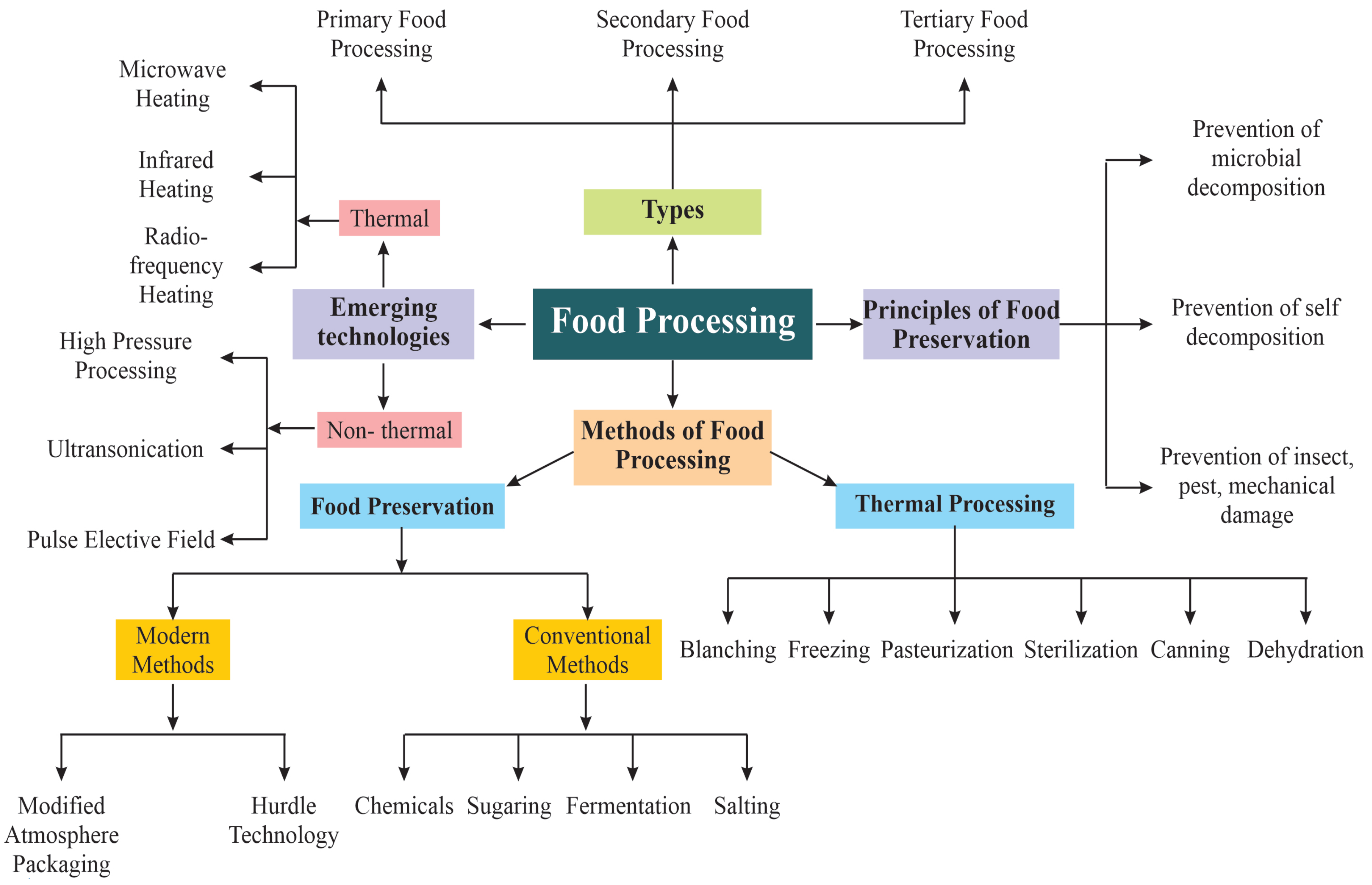
2. Sinha, S. P. (2012). *Principles of Food Processing*, Adhyayan Publishers & Distributors, New Delhi.

WHAT YOU HAVE LEARNT



18

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VALUE ADDED FOOD PRODUCTS

Value addition is the process of transforming a raw commodity into a high-quality end product. In the case of food products, value addition results in the production of highly nutritious products with excellent quality, longer shelf life, and improved food safety. While value addition is often pursued for profit, it is also undertaken to improve the nutritional quality of food products. This process can be as simple as grading fruits and vegetables by size and packaging them uniquely, or as complex as transforming them into jams, jellies, chutneys, squashes, etc.

In this lesson, we will learn about the importance of value addition in foods, as well as various value added food products derived from fruits, vegetables, cereals, and milk.

LEARNING OUTCOMES

After studying this lesson, the learner:

- defines the value addition;
- lists the different methods used for value addition of foods;
- explains the value addition of fruits and vegetables and different value added products;
- describes the value addition of cereals and various value added cereal products; and
- outlines value addition in milk and different value added dairy products.

18.1 VALUE ADDITION

A value added food product refers to any product that has been subjected to additional processing or been combined with other products/components to increase its overall value. Value added food products have been modified or enhanced to have a higher market value and a longer shelf life.

Notes

18.1.1 Importance

The importance of value addition in case of different food products can be understood through the following points:

- Provides profitability to farmers and financial stability to farmers
- Increases employment opportunities
- Offers better quality, safe, and branded foods to consumers
- Promotes primary and secondary processing industries
- Reduces post-harvest losses
- Reduces imports and meets export demands
- Enhances foreign exchange opportunities
- Encourages the growth of the dairy industry
- Reduces the economic risks associated with marketing

18.1.2 Range of Value Added Food Products

- Fruits and vegetables are processed into a variety of food products, such as juices and concentrates, pulp, canned and dehydrated products, jams and jellies, marmalades, pickles, and chutneys, etc. The extent of processing of fruits and vegetables varies from one country to another.
- Value added cereal products include biscuits, corn flakes, bread, pasta, noodles, and other bakery products, milled products.
- Value addition in milk boosts the economy of the farmers and the dairy industry, simultaneously. This is done by processing milk into products like pasteurized milk, sterilized milk, khoa, paneer, ghee, cheese, yogurt, ice cream, butter, and other dairy items, etc.

Similarly, value addition in case of other food products, such as meat, fish, and poultry, when coupled with effective marketing, has the potential to reduce agricultural wastage, create jobs, and ensure better prices for producers.

ACTIVITY 18.1

Collect various value added food products. Group them based on their sources.

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18.2 TECHNIQUES FOR VALUE ADDITION OF FOOD PRODUCTS

18.2.1 Food Fortification

Fortification of foods means the process of improving the nutritional quality of food by adding essential vitamins and minerals (micronutrients). The objectives of food fortification are to:

- Improve the nutritional value of food products.
- Address health issues caused by nutrient deficiencies.
- Provide a variety of food products with improved nutritional profiles.
- Restore nutrients lost during food processing.
- Add nutrients that may not be naturally present in the food.

The methods of food fortification are divided into four types. They are named according to the method used for fortification.

- Bio-fortification
- Industrial fortification
- Synthetic fortification
- Home fortification

18.2.1.1 Bio-fortification

This technique involves the genetic modification of crops or conventional breeding of

Notes

crops to increase their micronutrient content. For example, "Golden Rice" is a bio-fortified crop that contains higher levels of iron and beta-carotene compared to normal rice. This technique has gained more attention in recent years.

Advantages

- A large group of the population gets benefitted from this technique.
- It requires minimal changes to existing practices.

Disadvantages

- Strict food regulations and strict quality control are required.
- Sensory changes in the food products may be unappealing to consumers.

18.2.1.2 Industrial Fortification

This method of fortification improves the nutritional quality of industrially processed and widely consumed edible food products such as flour, oils, rice, butter, sauces, etc.

Advantages

- Food products can be made available at cheap prices.
- Restores the micro-nutrients lost during processing
- It does not interfere with the natural state of plant and animal species.

Disadvantages

- Some people are too far from the markets to purchase food products.

18.2.1.3 Synthetic Food Fortification

This method of fortification involves the addition of probiotic bacteria such as lactic acid bacteria, to food products to improve their nutritional quality.

Advantages

- It requires minimal changes to existing food products.

Disadvantages

- Sensory changes in the food products may make it less appealing to consumers.

18.2.1.4 Home Fortification

Home fortification involves providing micronutrients in packages or tablets that can be added when cooking or consuming meals at home, such as vitamin D drops. This method of food fortification can improve the diet of young children.

Advantages

- Does not alter the natural state of plant or animal species
- Inexpensive to distribute

Disadvantages

- Requires proper knowledge about food ingredients and their use
- Some people may feel uncomfortable adding a substance to their food without understanding its purpose.

18.2.2 Food Enrichment

An enriched food is a type of food that has been fortified with additional nutrients. These nutrients were originally present in the food, but were lost during the processing stages. For instance, white bread is a commonly consumed enriched food, where certain vitamins are added during the refining process, thereby improving its nutritional value.

Difference between Food Enrichment and Fortification

Food enrichment is the addition of micronutrients lost during processing, while food fortification is the process of improving the nutritional quality of food by adding essential micronutrients that may or may not be have been present in the original product.

18.2.3 Packaging

Packaging plays a key role in preserving the quality of processed food products and improving their shelf life, presentation, and marketability. Although food packaging (Fig. 4.1) does not directly contribute to value addition in food products, it helps to maintain their existing quality. Additionally, the materials used for packaging should not have any adverse effect on product quality or safety.

Notes

Fig. 18.1 Food Packaging

18.2.4 Innovation

By using innovative techniques, new food products can be developed with improved shelf life, better food quality, and increased safety.

18.2.5 Preservation

Certain forms of preservation can also help maintain the nutritional quality of food products. For example, freezing or canning can preserve some of the nutrients in the food.

INTEXT QUESTIONS 18.1

1. Fortification of foods means enhancing the ………………….. of foods by adding vitamins and minerals.
2. Different methods of food fortification are…………………………………
3. Bio-fortification includes techniques like …………………….. and …………………...………………..
4. Synthetic food fortification involves the addition of …………………… to food products.

ACTIVITY 18.2

List any three fortified foods. Identify the nutrients that are fortified.

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18.3 VALUE ADDED PRODUCTS OF FRUITS AND VEGETABLES

Value addition in fruit and vegetable processing refers to transforming raw commodities into processed products through the use of raw materials, labor, time, and technology in a way that increases economic returns. Typical value addition techniques for fruits and vegetables include cleaning, cutting, drying, packaging, and freezing. Examples of value added products from fruits and vegetables include:

- Pulp
- Juices and concentrates
- Canned and dehydrated products
- Jams and jellies
- Pickles, chutneys, etc.

The concept of value addition in fruits and vegetables is a strategy to reduce post-harvest losses of fresh produce, extend the storage period, and ensure the availability of fruits and vegetables during off-seasons.

18.3.1 Preparation and Preservation of Juice Products

Fruit juices (Fig. 18.2) have their best taste, aroma, and color when freshly extracted. The most important steps in processing fruit juices are

(i) Selection and preparation of fruit

(ii) Extraction of juice

(iii) Deaeration

(iv) Straining, filtration, and clarification

Notes

(v) Preservation

All fruits are not suitable for making fruit juice, either because of difficulties in juice extraction or because the resulting juice is of poor quality. Fruits or vegetables have to be thoroughly cleaned to remove any dirt or insecticide residues. The method of juice extraction will vary depending on the structure and composition of the fruit. Before pressing, most fruits are crushed to facilitate extraction.

The extraction of juice should be done as quickly as possible, and the juice should be exposed to the open air as little as possible. Fruit juice contains some air, which is either present on the surface or dissolved within the juice. After extraction, the juice is strained and filtered to remove seeds, pulp, gums, pectic substances, and proteins in colloidal suspensions. The clarification of juice (complete removal of all suspended materials from the juice) can be performed by methods such as centrifugation, enzyme treatment, settling, filtration, freezing (-18°C), high temperature (nearly 82°C), and low temperature (-2 to -3°C).

Fig. 18.2 Fruit Juice

18.3.2 Fruit Beverages

Synthetic drinks contain only water (about 88%) and carbohydrates (about 12%) and provide about 48 kcal per 100 ml. In contrast, fruit-based drinks contain vitamins (A, B, and C) and minerals (iron, calcium, etc.) and provide more calories. Fruit beverages are easily digestible, highly refreshing, thirst-quenching, appetizing, and nutritionally far superior to many synthetic and aerated drinks. They can be classified into two categories: unfermented and fermented beverages.

18.3.2.1 Unfermented Beverages

Fruit juices that do not undergo alcoholic fermentation are referred as unfermented beverages. They include RTS (ready-to-serve) drinks, nectar, cordial, squash, crush, syrup, fruit juice concentrate, fruit juice powder, as well as barley water and carbonated beverages.

Notes

1. Juices

Juices may be natural, sweetened or blended.

- **Natural juice (pure juice):** It is the juice extracted from ripe fruits and contains only natural sugars.
- **Sweetened juice:** It is a liquid product containing at least 85% juice and 10% total soluble solids.
- **Blended juices:** These are made by mixing two or more juices to create a well-balanced, rightly flavored, highly palatable and refreshing drink.

2. Ready-to-serve

This is a type of fruit beverage that contains at least 10% fruit juice and 10% total soluble solids, and approximately 0.3% acid. It is called ready-to-serve (RTS) because it does not require dilution before consumption (Fig. 18.3).

Fig. 18.3 Ready to serve beverage (RTS)

3. Squash

This is a type of fruit beverage that contains at least 25% fruit juice or pulp and 40 to 50% total soluble solids. The squash contains added citric acid, sucrose, and preservatives (Sodium Benzoate or KMS). It must be diluted before serving.

Notes

18.3.2.2 Fermented Beverages

Fermented beverages are fruit juices that have undergone alcoholic fermentation by yeasts. Examples include wine and champagne (from grapes), port, sherry (Spanish wine), tokay, muscat, perry (from pears), orange wine, berry wine (from fruits like strawberry, blackberry), nira (from juice of the palm tree), feni (from cashew apple), and cider (from apple, bael, jamun, phalsa and, aonla).

1. Wine

Wine (Fig. 18.4) is a fermented alcoholic beverage made from grape juice without distillation. Wines are categorized based on alcohol content:

- Light wines: 7 to 9% alcohol
- Medium wines: 9 to 16% alcohol
- Strong wines: 16 to 21% alcohol

Sparkling wines contain carbon dioxide, while still wines do not. Fortified wines contain added alcohol in the form of brandy. Brandy is prepared by distillation of wine.

Fig. 18.4 Wine

18.3.3 Jam

Jam is a semi-solid food product prepared by cooking sugar with fruit or vegetable pulp, pectin, acid, and other ingredients to achieve the desired consistency. Jam should contain 68% solids and 45g of fruit pulp per 100g of jam. It can be prepared from one type of fruit or from two or more types. Common fruits used in jam preparation include apple, pear, sapota, apricot, loquat, peach, papaya, carrot, strawberry, mango, grapes, pineapple, etc.

Generally the fruit pulp is cooked with the required quantities of sugar and pectin, and the desired amount of citric acid is then added. The end-point is judged by either TSS (68%), boiling point (105°C), or the sheet test. The product is hot-filled into sterile bottles, followed by cooling, waxing, and capping. The final product is stored at room temperature.

18.3.4 Fruit Preserve (Murabba)

These are made from mature, under-ripe fruits by cooking large cut pieces or small whole fruits in heavy syrup until they become tender and transparent. The procedure includes peeling, puncturing (to promote sugar penetration), blanching (to inactivate enzymes), and chemical treatment, followed by the addition of sugar concentrate.

18.3.5 Pickles

Pickles (Fig. 18.5) are good appetizers that enhance the palatability of meals. Pickles are edible product preserved in a solution of common salt and vinegar.

Pickles can be prepared from fruits and vegetables such as lemon, aonla, mango, onion, cauliflower, cabbage, cucumber, bitter gourd, jackfruit, turnip, etc. Fruits are generally preserved in sweetened and spiced vinegar, while vegetables are preserved in salt.

Fig. 18.5 Pickles

- **Preservation with salt:** This method of preservation is generally used only for vegetables that contain very little sugar. The method involves adding salt to the prepared material, such as mangoes, and leaving the mixture in the sun for one week with shaking twice a day. Then, the required amount of spices is added, and the pickle is stored at an appropriate temperature.

Notes

- **Preservation with vinegar:** In this method, vegetables are preserved in vinegar until they reach a final concentration of 2-3% acetic acid (not less than 2%) for preservation. In vinegar pickles, salt (2-3%) and sometimes sugar (2-5%) are also added. Garlic, chillies, etc., are preserved in vinegar as such.

- **Preservation with oil:** The fruits or vegetables should be completely immersed in edible oil. The pieces of (lemon, cauliflower, turnip, etc.) are mixed with spices and salt. The mix is kept in the sun for 4-6 days, then oil is added to the mix.

- **Preservation with salt, vinegar, oil and spices:** Pickles can also be preserved by combining salt, vinegar, oil, and spices, such as in mango pickles.

18.3.6 Chutneys

A chutney is essentially a mixture containing fruit or vegetables, spices, salt and/or sugar, vinegar. The method of preparation is similar to that of jams, except that spices and vinegar are added. Ripe fruits/vegetables are slowly cooked below the boiling point. Onion and garlic are added at the start to mellow their strong flavors. Vinegar, sugar, and spices are added just before the final stage of boiling.

18.3.7 Tomato Products

The quality of tomato products is judged by their color, which is dependent on the redness of tomatoes used. During processing of tomato products, avoid prolonged heating and cool the product quickly after preparation.

i. Tomato Juice

Good quality juice should have a deep red color, possess the characteristic taste and flavor of tomatoes, uniform appearance, and high nutritive value. It should contain about 0.4% acid (in terms of citric acid), 0.5% salt, and 1% sugar.

ii. Tomato Puree

Skinless and seedless tomato pulp, with or without added salt, containing not less than 9% of salt-free tomato solids is known as "Medium Tomato Puree". It can be further concentrated to create "Heavy Tomato Puree", which contains not less than 12% solids.

iii. Tomato Paste

Tomato paste is similar to tomato puree but has a higher solid concentration. It is prepared by concentrating tomato juice through evaporation under vacuum. Tomato paste contains not less than 25% tomato solids, while "concentrated tomato paste" contains not less than 33% tomato solids.

iv. Tomato Sauce and Ketchup

Tomato sauce and ketchup are essentially the same, but sauces are generally thinner and contain more total solids (minimum 30%) than ketchups (minimum 28%). They are made with strained tomato juice or pulp, spices, salt, sugar, and vinegar, with or without onion and garlic, and contain not less than 12% tomato solids and 25% total solids.

Tomato ketchup is a condiment that is made by concentrating tomato paste with water, sugar, vinegar, salt, and seasonings.

18.3.8 Drying

Drying is the most popular method of food preservation. It removes water from the surface of the food through the combined effects of air flow, temperature, and humidity. Fruits and vegetables are dried to such an extent that their moisture content is reduced, which prevents the growth of microorganisms and inhibits the action of enzymes. Dehydrated fruit may contain 12-14% water, while vegetables should be dried to 4-8% water content, depending on the type, as they contain less sugar.

INTEXT QUESTIONS 18.2

1. What is value addition?

   ....

   ....

2. The most important steps in processing fruit juices are...................................

   ....

3. Different methods used for juice clarification are...

   ....

4. Fruit juices which do not undergo alcoholic fermentation are termed as.................

5. ....is a liquid product which contains at least 85% juice and 10% total soluble solids.

6. A fruit beverage which is not diluted before serving is known as..........................

7. .... is a fermented alcoholic beverage produced from grape juice without distillation.

8. Tomato juice is concentrated to not less than .... tomato solids in the case of tomato paste.

ACTIVITY 18.3

Identify and gather five value-added products made from fruits and vegetables. Examine and analyze the processes involved in enhancing their value.

....

....

....

18.4 VALUE ADDED PRODUCTS FROM CEREALS

Value addition is a process by which cereal grains are modified to enhance their value and appeal to consumers. The various value added products derived from cereals are explained below:

18.4.1 Value Added Rice Products

a) Instant Rice (Quick-cooking Rice)

Instant rice is prepared by dehydrating cooked rice to create a porous structure in the finished product. The cooked rice is first dehydrated in an air dryer and then subjected to a puffing treatment.

b) Puffed Rice from Paddy

To produce puffed rice, paddy is first soaked in water until its moisture content reaches about 20%. The moist paddy is then exposed to sudden heat treatment at 250-270°C for 30-40 seconds. This causes the husk to split off and the rice to puff up.

c) Rice Flakes (beaten Rice)

The rice is soaked in hot water (70-80°C) for 20 minutes. Thereafter the water is drained off, and the soaked rice is toasted in a pan at about 250-275°C until a few grains start puffing. The toasted rice is immediately subjected to flaking.

d) Rice Flour

Rice flour is added to other ingredients to enhance their utility. For example, adding rice flour to gram flour during the preparation of *pakoras* improves crispiness.

Notes

18.4.2 Value Added Wheat Products

Wheat is unique among other cereal flours as it has the ability to form dough with water. The various products prepared from wheat flour include *chapatti*, bread, biscuits, cookies, pasta products, and more.

a) Cookies

Cookies (Fig. 18.6) are soft wheat-based chemically-leavened products with high sugar, shortening content (fats like margarine, lard, vegetable oil) and relatively have low water content. The leavening is achieved through carbon dioxide, water or ethanol vapours, ammonia, and air. The most common leavening agent is sodium bicarbonate, which is low cost, non-toxic, easy to handle, and leaves no taste in the final product.

Fig. 18.6 Cookies

The major steps involved in cookie preparation include:

- Creaming the fat and powdered sugar to make a fluffy mixture.
- Sifting together the dry ingredients (flour, salt, and baking powder).
- Mixing the dry ingredients into the fat-sugar cream mixture with limited water.
- Forming smooth dough.
- Sheeting the dough and cutting it with a rotary cutter.
- Baking at 210°C for 9-10 minutes.

b) Cakes

The cakes differ from cookies in following aspects:

a) Higher sugar level

b) The main structural ingredients are fat and eggs.

c) Tendering agents include sugar and fat.

Cakes are of two types;

- Shortened cakes (containing butter or fat)
- Sponge cakes (without fat).

A higher level of gluten is not desirable in cake making. The cakes are baked at 190°C for 30 minutes.

c) Biscuits

In order to prepare biscuits, initially a mixture of five parts flour and one part milk is combined with baking powder, fat, and salt to create a dough.

The procedure includes:

Mixing the ingredients → Kneading the dough for 10-20 minutes to achieve the desired cohesion → Sheeting → cutting the dough to the desired size → Baking at 210-232°C for 15 minutes.

An under-kneaded dough results in biscuits that are very tender, coarse in texture, small in volume, and have a rough crust. The optimum kneading time of 10-20 minutes will give a fine structure, smooth crust, and better appearance. Over-

kneading results in a compact and tough biscuit.

d) Pasta Products

The pasta products (Fig. 18.7) are cost effective, easy to prepare, palatable, versatile, have a long shelf life, and have good nutritional value. The process involves sieving, purifying, and conditioning the dough by adding water, extruding it, and drying it until it reaches moisture content of 2%. The mixing process must be carried out in the absence of air to prevent air bubbles from appearing on the product's surface, otherwise which would result in an opaque appearance. This opaque color interferes with the perception of the yellow color of pasta.

Fig. 18.7 Pasta

INTEXT QUESTIONS 18.3

1. The moist paddy is puffed by subjecting to sudden heat treatment at ……….°C for …………….seconds.
2. Cookies are baked at ………………..°C for …………… minutes.
3. Cakes are of two types…………………. and ……………………………

18.5 VALUE ADDED PRODUCTS FROM MILK

Value addition in milk can be a great tool for enhancing the farmer's income and increasing profitability through the use of certain techniques. With rising consumer

Notes

awareness, people are more conscious about healthy diets, which has expanded the market for value added functional dairy products. Some of these value added products are described below:

A. Pasteurized Milk

Pasteurization is the process of heating each and every particle of milk to a suitable temperature below the boiling point for a definite time to destroy all pathogenic microorganisms. Cooling of milk immediately after pasteurization is essential because not all bacteria are killed during the heating process.

Temperature-time combination for LTLT (low temperature long time) is 63°C for 30 minutes. Temperature-time combination for HTST (high temperature short time) is 72°C for 15 seconds.

B. Sterilized Milk

Sterilization is a heat treatment method used to destroy both pathogenic and non-pathogenic microorganisms in milk. The milk is heated above 100°C for a specific time period to ensure that it remains safe for consumption for at least seven days at room temperature.

Generally, the milk is heated at 110°C for 30 minutes or 120°C for 15 minutes. When packaged in sealed bottles and stored at room temperature, sterilized milk can have a shelf-life of over six months. However, sterilization causes more nutritional loss than pasteurization, as vitamins B and C get destroyed during the process.

C. Butter

Butter is a fat concentrate obtained by churning cream, which gathers the fat into a compact mass and then process it further. It is a semi-solid product that contains no less than 76% milk fat and no more than 20% moisture. Butter is usually yellow or white in color, with a bland flavor and a slightly salty taste.

D. Cultured or Fermented Dairy Products

Lactose intolerance is a condition in which individuals cannot digest the sugar (lactose) in milk. However, fermented dairy products such as yogurt allow those with lactose intolerance to consume milk, as the fermentation process breaks down the lactose.

Fermented milk products such as yogurt and sour milk contain Lactobacilli bacteria, which naturally occur in the digestive tract and have a cleansing and healing effect. Introducing these products into the diet can help prevent the growth of certain harmful yeasts and bacteria that may cause illness.

The technology of cultured milk products, such as yogurt, curd, and cheese, is based on the microbial conversion of lactose to lactic acid, which gives these products their characteristic sourness. Lactic acid-producing bacteria are essential for this conversion process.

E. Curd (Dahi)

Curd is a fermented milk product obtained by souring pasteurized or boiled milk with lactic acid bacteria inocula.

F. Yoghurt

Yoghurt is a fermented milk product. In the manufacture of yoghurt, milk is typically heated to 70°C for 15-20 minutes, then cooled to 30- 40°C and inoculated with a mixed culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, in a ratio of 1:1.

G. Cheese

Cheese (Fig. 17.8) is produced from milk by the combined action of lactic acid bacteria and the enzyme rennin (also known as rennet). Like cream, which is a concentrated form of milk fat, cheese is a concentrated form of milk protein. Hard cheese should contain no more than 43% moisture and no less than 42% milk solids in the dry matter.

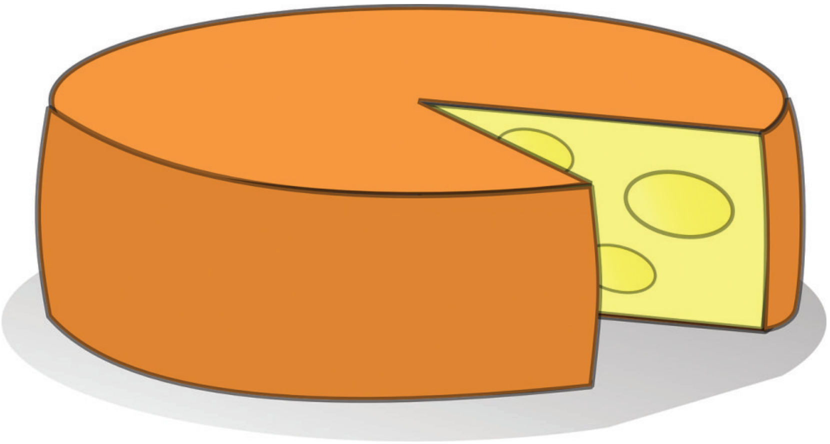


Fig. 18.8 Cheese

Notes

H. Ice Cream

Ice cream is a frozen dairy product made from milk, sugar, fat, and optional stabilizers, colors, and flavors. The product may include permitted stabilizers and emulsifiers that do not exceed 0.5% of its weight. The mixture must be heated sufficiently before freezing to destroy all pathogenic bacteria. Ice cream should contain at least 10% milk fat, 3.5% protein, and 36% total solids.

I. Dehydrated Milk Powder

Powdered milk is produced by evaporating liquid milk until it becomes dry. Drying of milk extends its shelf life and eliminates the need for refrigeration due to its low moisture content. Additionally, it reduces bulk, making transportation more economical. Types of milk powders include whole milk powder, non-fat dry milk, buttermilk powder, whey products, and dairy blends.

INTEXT QUESTIONS 18.4

1. Temperature-time combination for LTLT (low temperature, long time) pasteurization of milk is……………………………..
2. ………………………….. is the heat treatment of milk to destroy both pathogenic and non-pathogenic micro-organisms.
3. …………………..may be defined as a fat concentrate obtained by churning cream and gathering the fat into a compact mass.
4. Fermented-milk products such as yoghurt, contain bacteria from the …………………… group.
5. Cheese is made from milk by the combined action of………… bacteria and the enzyme………………………………………

WHAT YOU HAVE LEARNT

- Value addition leads to the production of highly nutritious products with excellent quality, shelf life, and food safety.
- Food enrichment involves adding micronutrients lost during processing, back into the food product.

- The concept of value addition for fruits and vegetables is aimed at increasing their storage life and ensuring availability during off-seasons.
- Juices can be natural, sweetened, or blended.
- Jam is a semi-solid food product made by cooking sugar with fruit or vegetable pulp, pectin, acid, and other ingredients to create a specific consistency.
- The quality of tomato products depends on the redness of the tomatoes used.
- Cookies, cakes, biscuits, and pasta are value-added wheat products that undergo specific processes for their production and development.
- Value addition in milk can be a great tool for enhancing farmers' income and increasing profit by using certain techniques.

TERMINAL QUESTIONS

1. What are the differences between pasteurization and sterilization?
2. Differentiate between fortification and food enrichment.
3. What is the importance of adding value to foods?
4. Explain the different methods of food fortification.
5. What are the advantages and disadvantages of each method of food fortification?
6. How can we prepare and preserve fruit juice products?
7. What is the difference between fermented and unfermented beverages?
8. How is fruit preserve prepared?
9. Explain the preservation of pickles with vinegar.
10. Differentiate between puffed rice and instant rice.
11. How are cookies prepared?
12. Why is mixing of pasta done under vacuum?
13. How is sterilized milk prepared?
14. How is ice cream prepared?
15. What is the composition of butter?

ANSWERS TO INTEXT QUESTIONS

18.1

1. Nutritional quality
2. Bio-fortification; industrial fortification; synthetic fortification; home fortification
3. Genetic modification, conventional breeding
4. Probiotic bacteria

Notes

18.2

1. Value addition is the transformation of a raw commodity or commodities into a processed product through the use of raw materials, labour, time and technology in such a way that assures increased economic return.
2. Selection and preparation of fruit, extraction of juice, deaeration, straining, filtration, clarification and preservation.
3. Centrifugation, enzyme treatment, settling, filtration, freezing (-18°C), use of high temperature (nearly 82°C) and low temperature (-2 to -3°C).
4. Unfermented beverages
5. Sweetened juice
6. Ready to serve
7. Wine
8. 25%

18.3

1. 250-270, 30-40
2. 210, 9-10
3. Shortened, sponge

18.4

1. 63°C/30 min
2. Sterilization
3. Butter
4. *Lactobacilli*
5. Lactic acid, rennin

GLOSSARY

Value added product: A value added product refers to any product that has been undergone additional processes or combined with extra products to increase its overall value and quality.

Dough: Dough is a semi solid mixture of flour, water and other ingredients like sugar, salt, leavening agents and flavours.

Chemical leavening: It is a process where a special compound (leavening agent like baking powder) is added to dough to release gas upon reacting with heat or moisture. This gas increases the volume of the baked product.

Fruit beverage: Fruit beverages are easily digestible and nutritionally rich fruit based drinks.

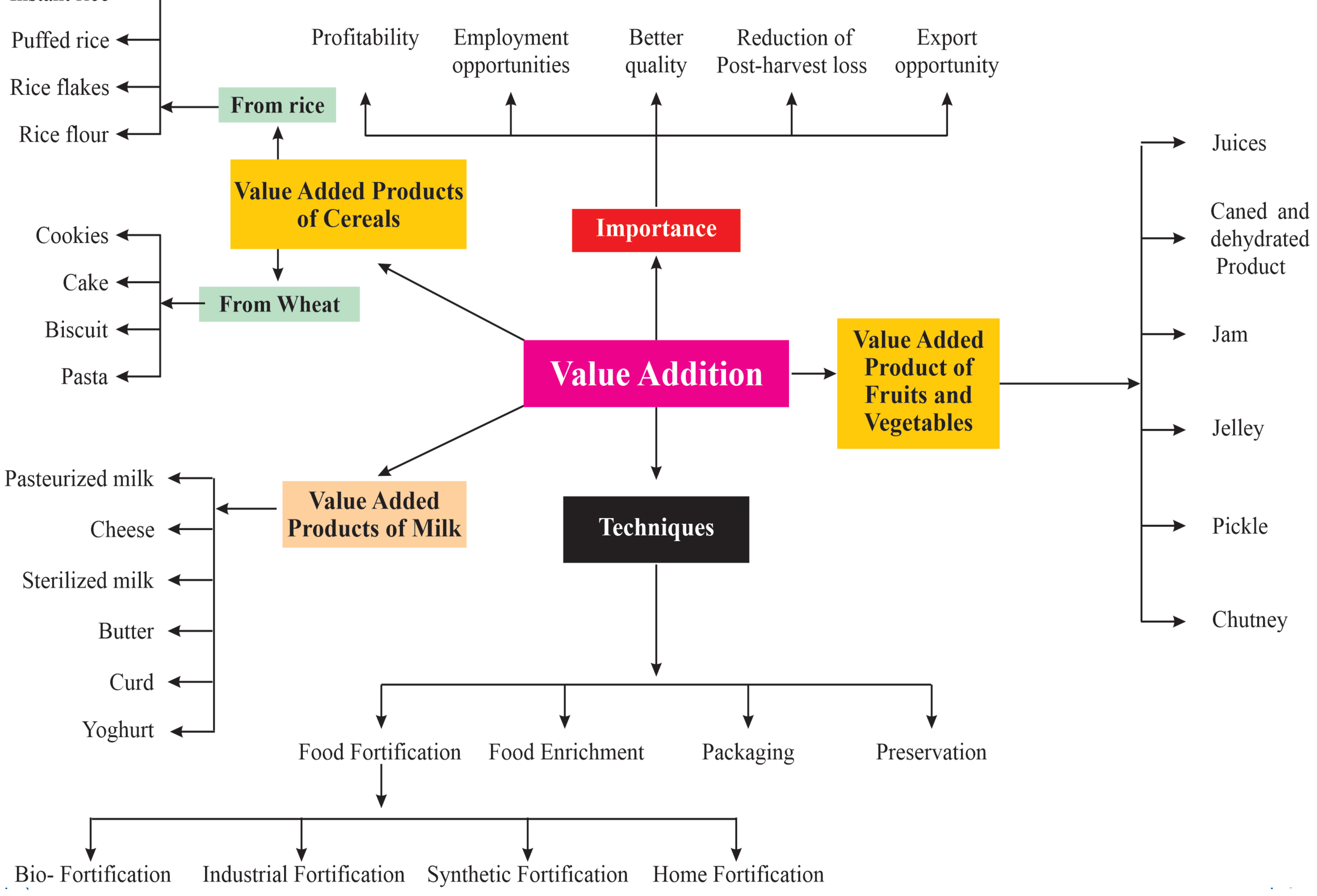
Jam: Jam is a semi-solid food product prepared by cooking sugar with fruit or vegetable pulp. It should contain 68% solids.

SUGGESTED READINGS

1. *Processing of Horticultural Crops*, B.Sc. (Horticulture), e-KrishiShiksha, Agricultural Education Division, Indian Council of Agricultural Research, New Delhi (https://ecourses.icar.gov.in/).

2. *Value addition,* TNAU Agritech Portal, Tamil Nadu Agricultural University, Coimbatore. (http://www.agritech.tnau.ac.in/horticulture/horti_valueaddition.html)

WHAT YOU HAVE LEARNT



19

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FOOD SAFETY AND QUALITY CONTROL

Food safety and quality are important at the home level, but they are critical in large-scale food production and processing, as well as in freshly prepared and served food. The quality of food products is determined by sensory attributes, chemical composition, physical properties, levels of contaminants, shelf life, packaging, and labelling. Understanding these quality characteristics and being familiar with the appropriate measuring tools is necessary for quality control and the quality assurance of food products. Advancements in technology and processing, higher per capita incomes, better purchasing power, and increased consumer demand have led to the manufacture of a variety of processed and functional foods. The safety of such foods needs to be assessed. In this lesson, we shall learn about the concept of food safety, different hazards involved in food safety management systems and practices, methods of food quality control, and the concept of food adulteration, including the different adulterants present in foods.

LEARNING OUTCOMES

After studying this lesson, the learner:

- identifies the characteristics of food quality;
- interprets the concept of food safety;
- differentiates between quality control and quality assurance
- evaluates various food safety management practices like GMP, GHP, HACCP; and
- discovers the features and functions of national and international food quality certifying bodies.

Notes

19.1 FOOD QUALITY

Quality is a term that denotes a degree of excellence, a high standard, or value. The quality of food may be defined as the combination of characteristics that differentiate individual units of a product and have significance in determining the degree of acceptability.

19.1.1 Characteristics or Attributes of Food Quality

A. Physical Characteristics

Appearance and color are important physical characteristics of food quality, described as follows.

- **Appearance**

  Factors such as size, shape, defects, and color are important appearance attributes that greatly influence the initial consumer acceptability of food products.

- **Color**

  Color is a quality factor that significantly influences the appearance of a product. It is a characteristic of light, measurable in terms of intensity and wavelength.

B. Chemical Characteristics

The nature and amount of substances in a given food product determines its nutritive value and other properties. The analysis of the molecular composition of food substances is used to study the protein, fat, carbohydrate, ash, and water content of foods.

- **Moisture Content**

  Moisture content is the most significant constituent in food products. As a medium, water supports chemical reactions, and therefore, removing moisture from food inhibits the growth of microorganisms, improving the shelf life of several food products. The following Table 5.1 provides an indication of the moisture content in different food products.

Table 19.1 Moisture content of different food products

Products	Moisture content (g/100g)	Products	Moisture content (g/100g)
Meat	65-75	Butter	16-18
Milk	87	Margarine	16-18
Fruit	70-90	Cereal flour	12-14
Vegetable	70-90	Coffee beans, roasted	5
Bread	35	Milk powder	4
Honey	20	Edible oil	0

- **Fat and Oil Content**

  Fat and oil quality depend on the composition of the food product, the size of the product, the type of processing, and the type of oil used. Higher fat products are more susceptible to rancidity, which is defined as the amount of free radicals that can cause an off-odor or off-flavor in foods.

- **pH-Acidity**

  The pH is an indicator of the amount of acid or base present in a food. pH also affects flavor, color, and texture and is measured using a pH meter.

- **Pigments**

  Pigments are compounds in food that give them color. For example, the green color of vegetables is due to chlorophyll, and the red color in tomatoes is due to lycopene.

19.1.2 Effect of Microorganisms

There are many types of microbes that can cause food borne diseases. These are discussed below:

- **Bacteria**

  Bacteria are the most important microorganisms for food processors. There are thousands of species of bacteria, but all are single-celled and fall into three basic shapes: spherical, spiral and rod.

- **Yeasts and Molds**

  Yeasts are oval-shaped and slightly larger than bacteria. Yeasts and molds grow on most foods, equipment, and building surfaces where there are small amounts of nutrients and moisture.

- **Viruses**

  Viruses are the smallest and simplest microorganisms. They are capable of infecting closely related species.

19.1.3 Sensory Attributes

Consumers accept food based on certain characteristics that they define and perceive with their senses. These attributes are sometimes referred to as qualitative or sensory qualities. They include color, size, shape, and physical aspects; other factors such as texture, viscosity, consistency, finger feel, and mouth feel; and flavor factors or sensations combining odor and taste.

- **Appearance and Color**

  Color and other aspects of appearance influence food appreciation and quality, especially by the consumer.

- **Texture**

  Texture can be described as the properties of a foodstuff that are sensed by touch in the mouth and with the hand.

- **Taste and Flavor**

  When food is consumed, the interaction of taste, odor, and texture provides an overall sensation that is best defined by the term “flavor”. Flavor is the most important sensory property of many food products.

INTEXT QUESTIONS 19.1

1. Quality is a term that denotes ....
2. Examples of physical properties determining food quality are ....
3. Color is a character of light, measurable in terms of .... and ....

4. Rancidity is defined as ....

5. The pH is an indicator of the amount of.......... or .... present in a food.

6. .... are the compounds in food that give them color.

7. Three basic shapes of bacteria are ...., ... and ....

8. ....are the smallest and simplest microorganisms.

19.2 METHODS OF FOOD QUALITY CONTROL

Quality control involves maintaining the standards that ensure food products meet the acceptable quality criteria of customers. The primary objective of food quality control is to protect the consumer. To ensure consistency and standardization of these procedures, food laws and regulations cover various aspects, including marketing, production, labeling, use of food additives, dietary supplements, enforcement of good manufacturing practices (GMPs), hazard analysis and critical control points (HACCPs), federal laws and regulations, factory inspections, and import/export inspections.

INTEXT QUESTIONS 19.2

1. GMP stands for............................

2. HACCP means..

19.3 FOOD QUALITY INSPECTION

Food quality inspection, as defined by the International Organization for Standardization (ISO), involves measuring, examining, and testing one or more characteristics of a food product and comparing the results against specific requirements to determine whether they meet the required standards.

19.3.1 Objectives of Food Quality Inspection

- To separate poor quality products from good quality products
- To increase the reputation by protecting customers from receiving poor quality products

- To ensure that the quality policy is followed
- Successful inspection helps in timely delivery of products
- To earn a reputation in the market

19.3.2 Stages of Inspection

- Inspection of incoming raw materials
- Inspection of production process
- Inspection of finished goods

19.3.3 Drawbacks of Inspection

- Inspection adds to the cost of the product without adding value.
- It is partially subjective; the inspector often has to judge whether a product passes or not.
- Inspection merely separates good and bad items; it does not prevent the production of bad items.

19.3.4 Difference between Food Inspection and Food Quality Control

Inspection assesses the manufacturing of non-conforming products and acts as a filter to remove them from the production flow (Reactive system).

Quality control attempts to prevent the manufacture of non-conforming products in the first place and attempts to predict, reduce, or eliminate the causes (Proactive system).

INTEXT QUESTIONS 19.3

1. Food inspection is a ……………... system, whereas quality control is a ………... system.
2. The stages of food quality inspection are ………………………………
3. ISO stands for……………………………………

19.4 FOOD QUALITY CONTROL (QC)

It is the procedures that a company must follow to ensure that its products meet food quality regulations and acceptable standards, thus ensuring consumer safety.

Some of the other food quality control procedures include product standards, Critical Control Point (CCP) identification, label specifications, cleaning and sanitizing programs, recall programs, and warehousing and shipping.

19.4.1 Purpose

- Provide routine and consistent checks to ensure data integrity, correctness, and completeness
- Identify and address errors
- Document and record all quality control (QC) activities

Higher QC activities include technical reviews of source categories, activity and emission factor data, and methods.

19.4.2 Importance and Functions

Quality control ensures the production of high-quality products, which is immensely helpful in attracting more customers and increasing sales. It is significantly beneficial for maintaining existing demand and creating new demand for the company's products.

19.4.3 Difference between Quality Control and Quality Assurance

Quality Control (QC) is a system that verifies and maintains a desired level of quality in an individual test or process. On the other hand, Quality Assurance (QA) is a part of quality management that focuses on providing confidence that quality requirements will be fulfilled. Table 18.2 presents the main differences between QC and QA.

Table 19.2 Difference between quality control \ (QC) and quality assurance (QA)

QUALITY ASSURANCE	QUALITY CONTROL
A medium to long-term process; cannot be implemented quickly	Can be implemented at short notice.
Focus on processes- how things are made or delivered	Focus on outputs- work-in progress and finished goods.

Notes

Achieved by improving production processes	Achieved by sampling & checking (inspection)
Targeted at the whole organization	Targeted at production activities
Quality is built into the product	Defected products are inspected out

INTEXT QUESTIONS 19.4

1. QA stands for ....
2. QC stands for ....
3. Quality control is a long-term process (True/False).

19.5 FOOD SAFETY

19.5.1 Definition

Food safety refers to the practices observed during the handling, processing, and distribution of food to ensure that contaminants that can cause foodborne illnesses are not present. Food safety is an important aspect of food production and handling as it protects the health and safety of consumers from any food-related issues.

19.5.2 Food Safety and Hazards

Knowledge of food safety is very important and can be improved by understanding '**toxicity**' and '**hazard**'. These two terms can be defined as follows:

- **Toxicity** is the ability of a substance to create harm under specific conditions.
- **Hazard** is an estimation that toxicity will happen if a substance is not used properly by following prescribed terms and conditions. Hazards are categorized into three types: physical, chemical, and biological. Each type of hazard can cause adverse effects on the health of consumers.

  a) **Physical hazard** is any physical material not typically found in food that can cause harm to consumers' health.

  Sources of physical hazards

  - Materials from the field like stones, insects, wood, insects etc.

Notes

- Materials arising from handling and food processing operations such as bones, metal, wood, bolts, glass, wire etc.
- Materials entering food products during distribution like metal, insects etc.
- Materials intentionally placed in food by employees.

b) **Chemical hazards** are chemicals or unwanted substances added intentionally or unintentionally to foods. Examples include pesticides, several additives, chemical residues, toxic metals, etc.

c) **Biological hazards** are living organisms and include microorganisms associated with food, which cause diseases known as foodborne pathogens. There are two types of foodborne diseases caused by pathogens i.e., food infection and food poisoning.

The various food safety hazards are presented in Fig. 19.1.

Fig. 19.1: Various Food Safety hazards

19.5.3 Food Infection

Food infection is caused by the ingestion of a sufficient number of microorganisms of public health significance, resulting in illness. Examples of food infections include salmonellosis and listeriosis.

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19.5.4 Food Intoxication

Food intoxication is caused by the ingestion of bacterial toxins. Examples of food intoxications include staphylococcal poisoning and botulism.

Among the various hazards, biological hazards are of significant concern in the context of foodborne illness. It is important to understand several key terms related to food safety, including contamination and adulteration.

19.5.5 Contamination

Contamination refers to the presence of harmful or objectionable substances in food items, such as microorganisms or chemicals, before, during, or after processing and storage. Major sources of food contamination include water, air, dust, equipment, sewage, insects, rodents, and employees.

19.5.6 Adulteration

Adulteration refers to the addition of inferior substances to food or the lowering of food quality by extracting valuable ingredients. Adulteration can be intentional or unintentional and may occur during processing, storage, transportation, and distribution of food.

19.5.7 Adulterants

Adulterants are substances that are added to make food products unsafe and unfit for human consumption. These adulterants can be present in all food products we consume daily, including dairy products, cereals, pulses, grains, meat, vegetables, fruits, oils, and beverages. Some common adulterants found in food products are presented in Table 19.3.

Table 19.3 Common adulterants in Foods

S. No.	Food Products	Adulterant
1.	Cereal grains	Dust, pebbles, stones, straw, weed seeds, damaged grain, etc.
2.	Sugar	Chalk powder, washing soda, urea, etc.
3.	Milk and curd	Water and starch powder

4.	Coffee powder	Chicory, tamarind seeds powder
5.	Pepper	Dried papaya seeds and blackberries
6.	Mustard seeds	Argemone seeds
7.	Edible Oils	Mineral oil, karanja oil, castor oil and artificial colours
8.	Tea	Artificial colouring agents
9.	Pulses	Dyes, chemical and lead chromate
10.	Ghee, cheese and butter	Mashed potatoes, vanaspati and starch powder

INTEXT QUESTIONS 19.5

1. Types of hazards are ……………………..., ………………….. and ……………

2. Presence of stone or wood in food material is an example of

   a. Chemical hazard b. Physical hazard

   c. Biological hazard d. None of these

3. Presence of a sufficient number of microorganisms in food may cause food infection (True/False).

ACTIVITY 19.1

Visit local shops and collect various food materials – both raw and cooked. Examine the foods for the presence of adulterants.

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19.6 FOOD SAFETY MANAGEMENT PRACTICES (FSMS)

Food safety has become a major issue throughout the entire supply chain in the food industry. Therefore, food manufacturers should take all preventive measures to eliminate

harmful substances from food. Government laboratories use analytical techniques to analyze food and detect toxic substances, as well as to ensure that the food is safe for consumers.

Notes

In addition to ensuring safe and healthy food for consumers, product manufacturers and service industries have realized that competition in a global market requires a continual and committed effort towards improving product and service quality. Therefore, they follow the process improvement cycle (PDCA), which comprises:

a) PLAN (plan improvement)

b) DO (implement plan for improvement)

c) CHECK (analyze the collected data)

d) ACT (take action)

A food hazard can enter food products at any stage of the food chain; therefore, proper control throughout the food chain is essential. Food safety and quality in food products can be ensured by following practices such as:

- Good Manufacturing Practices (GMP)
- Good Handling Practices (GHP)
- Hazard Analysis Critical Control Points (HACCP)

19.6.1 Good Manufacturing Practices (GMP)

GMP is an important tool that enables the reduction of food contamination and false labeling practices, thereby protecting consumers in all aspects of the food industry. Good Manufacturing Practices (GMPs) are the minimum sanitary and processing requirements necessary to ensure the production of wholesome food. GMPs are broad and general in nature, but their implementation results in safe and high-quality food.

Foundation of GMP

GMP is based on two components: effective manufacturing operations and effective food control operations.

Preliminary process in GMP

A manufacturing organization adopting GMP principles can:

- Consistently meet its own and customers' requirements.

Notes

- Meet industry standards and codes of practice.
- Comply with regulatory requirements.

GMP Activities

GMP is intended to build quality into the product at all stages of the operation. Good manufacturing practices are usually written for each of the following areas:

- Personnel
- Buildings and facilities
- Equipment and utensils
- Production and process control
- Records and reports
- Defect action levels and others

Benefits of GMP

GMP is a dynamic program that enables the organization to make and maintain quality improvements. An effective GMP program can offer several benefits to the organization including:

- Creates awareness of food quality and safety among the staff.
- Increases confidence in product safety.
- Provides a starting point for the HACCP program.
- Provides international recognition.
- Prevents expensive failures.
- Reduces customer complaints.
- Improves profits.

19.6.2 Good Handling Practices (GHP)

GHP ensures that all individuals who handle food follow good hygiene practices. GHP represents a systematic approach from the farm to the store or consumer to identify hazards and outlines procedures to minimize the risk of food contamination. It covers various aspects of the food industry, including the food supply chain, sanitation facilities,

Notes

workers' hygiene practices, pest control, and prevention of physical and chemical pollutants.

Purpose of GHP

The overall objective is to ensure that the food is safe for human consumption, by ensuring compliance with the basic hygiene and sanitary practices. These objectives include:

- Preventing illness caused by food consumption
- Assuring safe food for human consumption following certain principles
- Increasing the knowledge of food safety within the entire food supply chain by providing health education programs

Areas covered/examined under GHP

- Food production area
- Design and facilities in the production area
- Control of operation
- Maintenance and sanitation of plant
- Personal hygiene
- Transportation facilities
- Product information and consumer awareness
- Training for employees

19.6.3 Hazard Analysis Critical Control Point (HACCP)

HACCP is an approach to providing assurance about food safety. It involves the identification of hazards and the assessment of the likelihood of their occurrence at each step in the food chain. The HACCP system can be implemented at all stages of the food chain, from food production and preparation processes to packaging, distribution, etc.

Principles of HACCP

There are seven basic principles of HACCP.

- **Conduct a hazard analysis**: Plan to determine the food safety hazards and identify the preventive measures the plan can apply to control these hazards.

- **Identify critical control points**: A critical control point (CCP) is a point, step, or procedure in a food manufacturing process where control can be applied, and as a result, a food safety hazard can be prevented, eliminated, or reduced to an acceptable level.

- **Establish critical limits for each critical control point:** A critical limit is the maximum or minimum value to which a physical, biological, or chemical hazard must be controlled at a critical control point to prevent, eliminate, or reduce that hazard to an acceptable level.

- **Establish critical control point monitoring requirements:** Monitoring activities are necessary to ensure that the process is under control at each critical control point.

- **Establish corrective actions:** Corrective actions are necessary to ensure that no product is injurious to health.

- **Establish procedures for ensuring the HACCP system is working as intended:** Verification procedures may include activities such as review of HACCP plans, CCP records, critical limits and microbial sampling and analysis.

- **Establish record keeping procedures:** The HACCP regulation requires that all food processing plants maintain certain documents, including their hazard analysis and written HACCP plan, and records documenting the monitoring of critical control points, critical limits, verification activities, and the handling of processing deviations.

Benefits of HACCP

HACCP provides a systemic approach to food safety. The benefits of HACCP include:

i. Benefits to Consumers

- Reduction in the risk of food borne diseases
- Increased confidence in the food supply
- Increased awareness of basic hygiene
- Increased quality of life

Notes

ii. Benefits to Industry

- Increased access to markets
- Reduction in food wastage
- Increased customer confidence

iii. Benefits to Government

- Improved public health
- Reduction in public health costs
- Enhancement of international trade
- Increased confidence of the community in the food supply

INTEXT QUESTIONS 19.6

1. GHP stands for ………………………..
2. Identification of hazards, assessment of chances of their occurrence during each step in the food chain are important steps of

   a. GMP

   b. GHP

   c. GSP

   d. HACCP

19.7 CERTIFYING BODIES

India has a comprehensive system of product certifications governed by laws enacted by the Parliament of India. Key certifying bodies and standards include:

A. National Food Security Act (2013)

The Act aims to ensure food and nutritional security by providing access to adequate quantities of quality food at affordable prices.

Salient features

The major features of the Act are described below:

- The Act legally entitles up to 75% of the rural population and 50% of the urban population to receive subsidized foodgrains under the **Targeted Public Distribution System (TPDS)**.
- About two-thirds of the population is covered under the Act to receive highly subsidized foodgrains.

B. FSSAI (Food Safety and Standards Authority of India)

FSSAI is a government agency under the Ministry of Health and Family Welfare. It was established by the Food Safety and Standards Act of 2006 to supervise the activities and operations of food enterprises. It plays a crucial role in promoting public health by monitoring and regulating food-related activities. To ensure safety, all food distributors, processors, storage facilities, and retailers are required to obtain an FSSAI license.

FSSAI uses scientifically determined criteria to regulate a wide range of food products. It is responsible for setting hygienic standards for food manufacturing, storage, distribution, and warehousing. Furthermore, FSSAI aims to raise awareness among consumers about these standards to ensure their safety.

Basic principle

The Food Safety and Standards Act, 2006 defines food safety as the 'assurance that food is acceptable for human consumption according to its intended use'. Food safety ensures that the food is safe for human consumption and involves the proper handling, preparation, and storage of food to prevent food-borne illnesses.

Salient Features and Functions

- Promote general awareness about food safety and food standards.
- Frame regulations to establish standards and guidelines for food products.
- Provide scientific advice and technical support to the Central and State Governments on food safety policy.
- Establish procedures and guidelines for laboratory accreditation and notification of accredited laboratories.

- Collect data on food consumption, incidence and prevalence of biological risks, contaminants in food products, and identification of emerging risks.
- Create a nationwide information network to disseminate rapid information about food safety and related concerns to the public, consumers, and Panchayats.
- Provide training programs for individuals involved in or intending to start food businesses.

Notes

C. BIS

The Bureau of Indian Standards (BIS), formerly known as the Indian Standards Institute, is responsible for the development, maintenance, and application of standards for products, services, and processes in India. It verifies the quality and standard of products and issues a BIS certification mark. Legislation enacted in 1986 permits BIS to provide certification, and the BIS certification mark is mandatory for the sale of certain products in India.

Difference between ISI and FSSAI

ISI previously stood for Indian Standards Institute, but it has now been renamed to the Bureau of Indian Standards (BIS). Additionally, the mandatory certification mark is now referred to as the BIS certification mark rather than the ISI mark. BIS is responsible for the development, maintenance and application of standards for products, services, and processes in India. On the other hand, FSSAI is the authority responsible for setting guidelines for all food items manufactured and traded in India.

D. AGMARK

It is a certification mark used on agricultural products in India to ensure that they fulfil a set of requirements established by the Directorate of Marketing and Inspection, a government agency. Each product's grading criteria are determined using scientific methods. Samples of agricultural goods are collected from across the country, straight from the producing area, wholesale marketplaces, etc. These items are then tested in AGMARK Regional Laboratories. The standards are developed and framed based on the information gathered.

Notes

Objectives

- To provide customers with high-quality, hygienic food items
- To confirm the quality and purity of agricultural goods produced by local farmers

Benefits

- It increases the quality of crops.
- It stabilizes the prices of the crops.
- It facilitates peaceful resolution of market disputes.
- It makes interstate and international marketing more convenient.

E. ISO

ISO (International Organization for Standardization) standards are essential for improving food safety and hygiene in India and increasing the country's share in the global food trade. ISO has a series of international standards aimed at ensuring food safety throughout the supply chain. The ISO 22000 family addresses food safety management by providing guidelines and best practices for managing risks in all areas of food production.

ISO 9000 is an international reference for quality requirements, focuses on the "Quality Management" of an organization. Adoption of these standards is voluntary.

Key areas

Within its broad scope, the ISO 22000 family includes standards specific to catering, food manufacturing, farming, packaging, and animal foodstuffs and feed production.

Benefits

- It improves customer confidence in food safety.
- Demonstrates a commitment to supplying safe foods.

F. FPO

The Fruit Products Order Mark (FPO Mark) is a mandatory certification mark for all processed and packaged fruits in India. The Ministry of Food Processing

Notes

Industries is the regulatory authority responsible for certifying and developing standards for the manufacturing of fruit products in India.

Products covered under FPO

- Synthetic beverages
- Vinegar
- Pickles
- Dehydrated fruits and vegetables
- Squashes
- Jam, jelly and marmalades
- Tomato products
- Preserved, candied and crystallised fruits
- Chutneys
- Canned and bottled fruits, juices, pulps and vegetables
- Frozen fruit and vegetables etc.

G. International Codex Alimentarius

The Codex Alimentarius Commission (CAC) is an international food standards body established jointly by the Food and Agriculture organization (FAO) and the World Health Organization (WHO) in May 1963. Its objective is to protect consumer health and ensure fair practices in food trade.

Purpose

The main purpose of this programme is to protect the health of consumers, ensure fair practices in the food trade, and promote coordination of all food standards work undertaken by international governmental and non-governmental organizations.

Difference between Codex and ISO

Codex	ISO
The Codex is a set of international standards recommended for regulating food safety in different countries.	ISO standards are voluntary guidelines that focus on improving food safety management systems.

ACTIVITY 19.2

Visit a nearby hotel and observe the following:

- The area where food is prepared and served.
- How the food is prepared and stored.
- How the food is served.
- The food service area
- Washing area
- All persons involved in handling the food from pre-preparation to service.

Comment on the cleanliness and hygiene and give suggestions for improvement.

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Labelling requirements

Food label in the context of food safety is most crucial as it directly communicates important information to the consumer. The most important food labelling requirements that holds special place regarding food safety include:

- Name of the food
- List of ingredients in descending order
- Nutritional information
- Declaration regarding food (vegetarian or non-vegetarian)

Notes

- Declaration regarding food additives
- Name and complete address of the manufacturer or packer
- FSSAI logo and license number
- Net content by weight or volume
- Retail sale price
- Consumer care details
- Lot/Code/Batch identification
- Date Marking – "Date of manufacture or packaging" and Expiry/Use by and manner of declaration of date of manufacturer or expiry/use by
- Labelling of imported foods
- Country of origin for imported products
- Instructions for use
- Declaration regarding food allergens
- Symbol for food materials not meant for human consumption

INTEXT QUESTIONS 19.7

1. .... mark is a mandatory for all processed fruit products in India.
2. FSSAI stands for ....
3. Codex Alimentarius Commission is jointly formed by
   a. WHO & United Nations
   b. FAO & United Nations
   c. WHO & FAO
   d. United Nations & UNDP

WHAT YOU HAVE LEARNT

- Every food product has characteristics and indices that can be measured using sensory, physical-chemical, or microbiological methods.
- Quality of foods may be defined as the blend of those characteristics that differentiate individual units of a product and have significance in determining the degree of acceptability.
- Quality control refers to the standards that maintain the quality of food products according to the customer acceptability.
- According to ISO, inspection of food quality is defined as an activity of measuring, examining, testing one or more characteristics of a food product and comparing the results with specific requirements to determine whether conformity is achieved for each characteristic.
- Quality Control (QC) is a system of routine technical activities used to measure and control the quality of the food production process.
- Quality Assurance (QA) involves a planned system of review procedures conducted by personnel not directly involved in the food production process.
- Food safety means assuring the acceptability of food for human consumption.

TERMINAL QUESTIONS

1. What are the different factors determining food quality?
2. What are pigments? Give examples.
3. Explain the different types of microbes responsible for food borne-illness.
4. Define food quality control. Why is it important?
5. What is PDCA approach?
6. What are the objectives of food quality inspection?
7. What is the difference between food inspection and food quality control?
8. What are the differences between QA and QC?
9. What is the importance of food safety?
10. What is a hazard? How is it linked with food safety?

Notes

11. Explain the different types of hazards.
12. What is food adulteration? Give some examples.
13. What is the difference between GHP and GMP?
14. What is HACCP?
15. Explain the different principles of HACCP.
16. Discuss ISO and FSSAI.
17. What is the importance of FPO and BIS?

ANSWERS TO INTEXT QUESTIONS

19.1

1. Degree of excellence, a high standard, or value.
2. Appearance, color etc.
3. Intensity, wavelength.
4. The amount of free radicals that can cause an off-odor or off-flavor in foods.
5. Acid, base
6. Pigments
7. Spherical, spiral and rod
8. Viruses

19.2

1. Good Manufacturing Practices
2. Hazard Analysis Critical Control Point

19.3

1. Reactive, proactive
2. Inspection of raw material, inspection of production process and inspection of finish goods.
3. International Organisation for Standardization

19.4

1. Quality assurance
2. Quality control
3. False

19.5

1. Physical, chemical and biological
2. Physical hazard (option b)
3. True

19.6

1. Good Handling Practices
2. HACCP (option d)

19.7

1. Fruit Product Order
2. Food Safety and Standards Authority of India
3. WHO & FAO (option c)

GLOSSARY

Food quality control: It is the process of monitoring and maintaining food quality according to set guidelines to ensure that consumers receive safe and secure food.

Food contamination: The presence of harmful or objectionable substances in food items, such as microorganisms or chemicals, before, during, or after processing and storage is termed as food contamination.

Food adulteration: It is the addition of inferior substances to food or the lowering of food quality by extracting valuable ingredients.

Toxicity: The ability of a substance to cause harm under specific conditions.

Hazard: It is potential of a substance to cause toxicity. All toxic substances are hazardous, but not all hazardous substances are toxic.

GMP: Good Manufacturing Practices (GMPs) are the minimum sanitary and processing requirements necessary to ensure the production of wholesome food.

Notes

GHP: Good Handling Practices (GHPs) ensures that all individuals who handle food follow good hygiene practices.

SUGGESTED READINGS

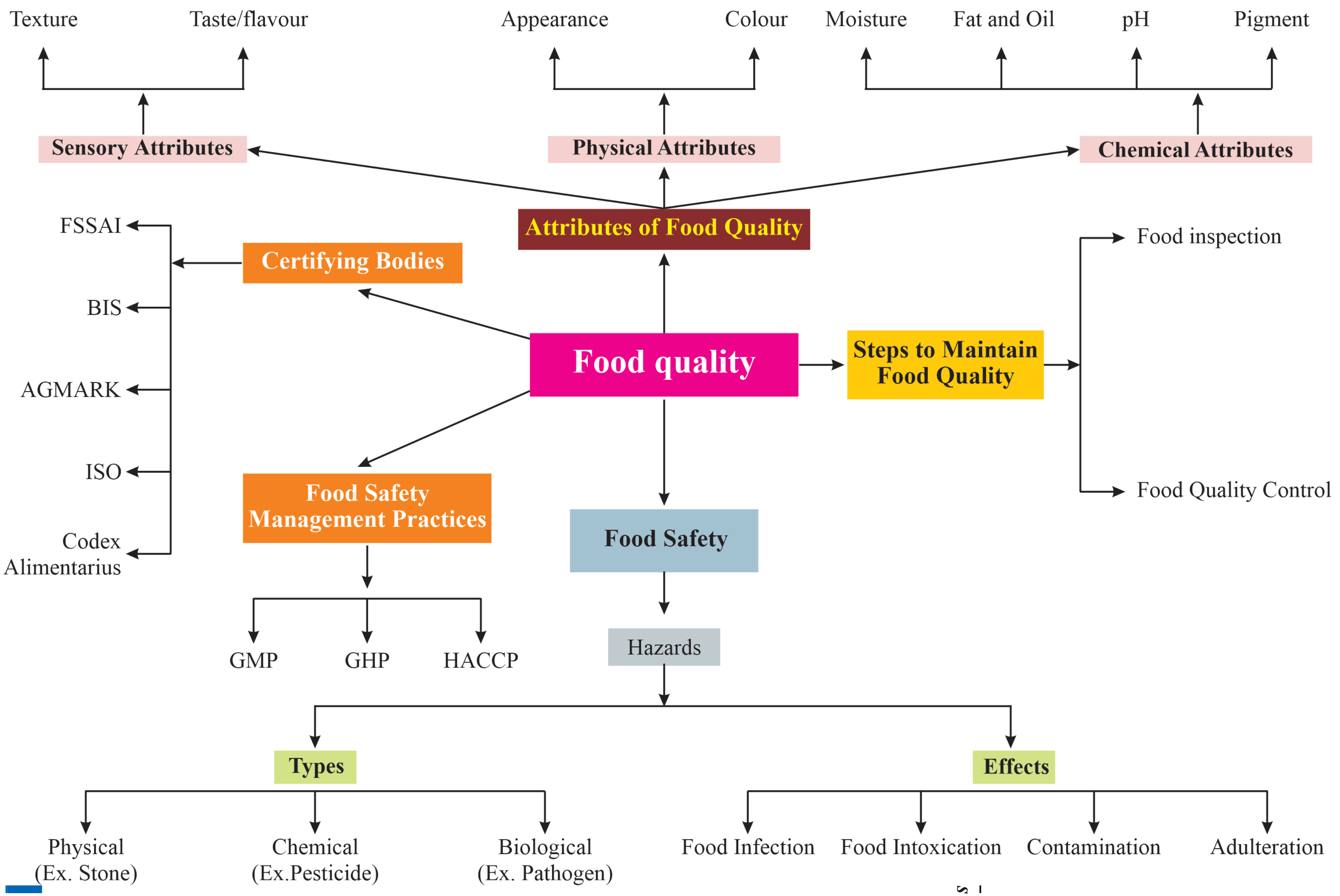
1. *Food Safety and Quality*, TNAU Agritech Portal, Tamil Nadu Agricultural University, Coimbatore.

   (http://www.agritech.tnau.ac.in)

2. *General Principles of Food Hygiene*, Food and Agriculture Organization, Rome, Italy.

3. *Principles of Food Safety and Quality Management*, eGyanKosh, Indira Gandhi National Open University, New Delhi.

WHAT YOU HAVE LEARNT



MODULE - 5

Agricultural economics, marketing and policy

20. Basics of Agricultural Economics

21. Agricultural Marketing and Policy

22. Agricultural Finance and Credit in India

20

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BASICS OF AGRICULTURAL ECONOMICS

To meet the total demand of the country through local production by using own resources need large quantity of inputs. But no nation has all the resources to produce everything. For instance, India does not have a championship in producing pulses and oilseeds. These are largely imported. So, the demand for these products by India is fulfilled from local production and also through imports. Similarly, within India, not all states produce everything. Cotton is largely grown in Maharashtra and Gujarat, while people across India wear cotton textiles. You must appreciate the fact that it is good to produce something when the resources to produce it are available at the least possible cost to generate profits. Only then the production is sustainable and the business expands. So far, we have used several important terms such as demand, supply, and costs. You shall learn the basic concept of agricultural economics in terms of demand, supply, price, and cost in this lesson.

LEARNING OUTCOMES

After studying this lesson, the learner:

- explains the importance of learning economics;
- describes agricultural economics in terms of definition, nature and scope;
- infers characteristics of Indian agriculture industry;
- identifies the factors of production;
- summarizes the concept of demand and supply as well as their factors;
- defines the cost and revenue concepts; and

- demonstrates the practical applications and utility of demand, supply, price, and costs.

20.1 ECONOMICS - IT IS ABOUT SCARCITY AND CHOICES

In simplest terms, economics is the study of choice under conditions of scarcity. Scarcity arises because our wants are unlimited while resources are limited. We have less labour, less land, less time, less spending power, and less income, resulting in a shortage of resources. As all these things have limitations, we are forced to make choices. We choose to eat but not spend on expensive food outside. We choose to buy clothes from a local brand to feel good and not spend on more expensive brands. Economists study these choices that individuals make and their consequences. They also study the direct and indirect impact of these choices on society. Therefore, the scarcity of resources and the choices we make related to them form the base of economics.

Households have to make choices regarding different goods and services since their income is limited. They have to allocate their resources efficiently between consumption expenditure and savings. Business firms have to spend on raw materials and pay for wages, among other expenses. As these firms have to make choices on what to produce and what not to, they do so wisely by limiting their costs and allocating resources effectively. The government also makes choices and allocates budgets for different developmental projects, announces policies and programs, and carefully chooses which goals to pursue. Economists study these decisions and try to explain how individuals, society, and systems work and behave in a certain way. Adam Smith who is considered as 'the father of economics' wrote a famous book called 'The Wealth of Nations' regarding this phenomenon.

20.2 PRINCIPLES OF ECONOMICS

Economics is about the scarcity and management of scarce goods and services by people. For example, it involves how people decide on what and where to buy, as well as at what prices they would like to purchase a product or service. It's all about making choices. We may encounter such questions daily, such as how to decide the amount of work to do, how much time to spend studying, or whether to go and play cricket or stay home and finish our lessons. Thus, under each of these scenarios, a choice has to be made with respect to time, which is a crucial resource. If you choose to go outside and play cricket, you will lose time for studying. Even if you wanted to do both, no two things can be done simultaneously. Spending more time playing cricket may reduce your time for any other activity, such as studying, listening to music, painting,

dancing, singing, or swimming, etc. Therefore, time has to be allocated in a way that maximizes the satisfaction derived from all of these activities. This is known as optimal allocation of resource (which here in this case is your time and labour).

When it comes to the economy, you may wonder how a firm (or a unit or a company) decides how much to produce. Is the decision of the firm guided by the price or the demand? How are demand and supply related to prices? Making such decisions is what economics is all about. Moving from people to firms and to the society, the society decides how much to spend on food and non-food items like health, education, etc. So, there seems to be an interaction between individuals and firms, and their interaction determines how much should be supplied for a particular demand. The prices at which the buyer agrees to buy and the seller agrees to sell are called the equilibrium price or market price.

The principles of economics therefore are categorized into three categories.

1. How do people decide?

2. How do people interact?

3. How does the whole economy work?

20.2.1 Principles of Individual Decision Making or How do People Decide

There are four economic principles related to it:

A. People make trade offs

The desire for the consumption of goods and services is limitless, but their production is limited by the availability of resources. For instance, you may want to grow all types of fruits, but your resources, including land, labour, and capital, are limited. Hence, you need to make decisions regarding which fruits to grow that can bring in the most profit with the existing resources. Therefore, the allocation of resources becomes crucial, and people have to make trade-offs. They have to sacrifice one goal to achieve another. You cannot grow all types of fruits, and you must prioritize the ones that align with your goals and available resources.

Similarly, if a society or nation decides to spend more on defence, it will have to spend less on other things like entertainment. However, it's crucial for a society to protect its borders from aggressors, so more spending is allocated towards safety and security rather than entertainment. This represents a trade-off; both

Notes

cannot be achieved as the budget is limited. Therefore, it's necessary to allocate the budget efficiently and effectively.

B. People sacrifice something to get another thing

Because resources are scarce by nature, one has to make trade-offs and sacrifice something to gain another thing. This is also known as the principle of opportunity cost. In the examples discussed above, society sacrificed entertainment to gain protection from enemies, and student sacrifices sleep to get good results. Why do you do that? Simply because we assess the returns of every choice over the cost paid for it. You chose and paid for the music class over a painting class only when you assessed that learning music could potentially lead to singing on stage and making millions of rupees, which a painter might not earn. In other words, you sacrificed painting over music because you believed that music would give you better returns.

C. People make rational decisions by thinking at margin

Several times, we often make decisions by making incremental or decremental adjustments. These are known as marginal adjustments and are a common phenomenon that we see in people around us. For example, taking an additional course in the next semester. You will analyze the situation and consider whether those extra credits are good for your focus and time allocation to other subjects. You will add courses as long as the additional or marginal benefits are more than the additional or marginal costs. Therefore, marginality is the principle of intelligent or rational decision-making. Being rational means thinking at the margin. You are rational when you decide not to have an extra slice of bread when you feel full. Eating more will not give you any benefit and might make you sick. This is rationality. Growing an extra acre of land does not mean that you have to buy an extra tractor. One tractor can serve that extra acre as well. This is rationality. When is it good to get an extra tractor? Think!

Another example is the **principle of diminishing marginal utility**. But what is 'Utility'? The total satisfaction derived by consumers from consuming these goods and services is called 'Utility'. 'Marginal utility' means the additional satisfaction that a consumer derives by consuming the additional unit of a product. It is a good way to understand how consumers make decisions. As the amount of satisfaction derived from the consumption of a commodity increases, the consumption of the good decreases. This is known as the **principle of diminishing marginal utility**, and is an effective principle in making choices.

Let us understand it from an example, when you are hungry, the first bite of food gives you satisfaction and as you finish your first bread, your satisfaction increases. There is a time when you feel full and are not able to derive same happiness anymore from third, fourth or fifth bread. So your consumption is limited by the level of satisfaction that you derived.

D. People respond to incentive

Old but true proverb. Yes, we all respond to incentives. Remember what your mom told you when you were a child and wanted her to buy you a chocolate? She would have told you to behave nicely or finish your homework, and you happily did it in anticipation of the chocolate. Have you ever noticed how quickly you grab items from the shelf in the supermarket if there's a discount or an attached offer? This is what an incentive means. We respond positively to bonuses and interest received, and interest makes us keep our money in banks or other financial instruments. This money goes into the economy of the nation and is utilized for different purposes to build the nation's economy. So incentives are important. Wearing a seat belt is an incentive as it can save your life.

ACTIVITY 1

Go to a big retail chain (i.e. shopping mall or showroom) of your area and check wheather any offer is available for products. See if you really got attracted to these offers or not. If you did, that means you responded to the incentives offered by the shop. Share your experience.

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20.2.2 Principles of how do people interact

Somebody's decisions may affect others. The decision to sell can also bring benefits to the buyer. There are several interactions in the economy of this kind. Therefore, this set of principles consists of three principles in total, which are:

A. Trade makes everybody better off

A country cannot produce everything and cannot stand in isolation. Therefore,

Notes

trade makes any country better off as some other country may produce what India is not producing or does not have resources to produce. As the world is now open with no boundaries, it is good to import from where there is a surplus. Trade balances demand and supply, stabilizes prices, and provides a large basket of consumption goods. It, therefore, makes everybody better off. This is also known as principle of comparative advantage.

B. Markets can organize a good economic activity

Markets are the places where the buying and selling of goods and services takes place. Households and firms interact with each other. Households make decisions related to what they want to consume and how much they can pay for it. They also provide labour. On the other hand, firms produce goods for these households by combining all the necessary resources, including labour. The interaction between households and firms leads to a market for labour (input) and finished goods (output).

C. Government's role is critical to improve market outcomes

Sometimes, markets fail to allocate resources effectively, and this is known as market failure. In such situations, the government can intervene and improve market outcomes. For example, in the absence of proper regulation, it is often found that pollution levels may be high or that there may be a high level of food adulteration. Laws and regulations help control these extremes and therefore improve market outcomes.

20.2.3 Principles of how the whole economy works

It covers three principles

A. **Any country's standard of living is guided by its ability to combine resources to produce different goods and services**

Around the world, countries differ from each other in the standard of living they provide for their citizens. Some parts of the world suffer from poverty, high mortality rates, high birth rates, low income, poor health and education, hunger, and malnutrition. Developed nations, on the other hand, do not face any of these issues. The level of effectiveness in combining resources plays a crucial role in determining a nation's prosperity. If a worker is more productive in America than in India, America can produce more in less time. This increased production may result in generating a surplus to export. Through export earnings,

incomes rise, leading to better consumption of food and non-food items, thereby improving the standard of living. However, if a country lacks resources or has scarce resources like water, it cannot produce a significant amount and heavily relies on imports. When you import, money goes out, and income does not improve, resulting in a lower standard of living. There are also countries that have resources, but they lack the technology to extract them. In such cases, someone else deploys the technology to extract these resources and exports them, and the money goes to the person who owns the technology, not the country where the resources are located. In this scenario, the standard of living of the country owning the resources does not increase. Please think about it!

B. Price rise when the government prints too much money

Persistent price rise in General Price Level is known as inflation. If more money is circulated in the economy to chase goods and services, prices rise and inflation prevails.

C. Society faces a short-run trade-off between inflation and unemployment

In the short run, the response of prices to changes in the quantity of money in circulation is very slow. Hence, even when the government reduces the quantity of money in the short run, prices do not change immediately (inflation still persists). As a result, the demand for goods and services goes down, affecting productivity which then decreases. Due to low production, firms start laying off workers, resulting in short-term unemployment.

INTEXT QUESTIONS 20.1

1. Too many demands chase too...........resources
2. The cost of giving up something to get something else is called...............
3. People have to make choice as they are limited by the.............
4. Rational people think at ....
5. Too much printing of money leads to ....

20.3 AGRICULTURAL ECONOMICS: DEFINITION, NATURE AND SCOPE

Definition:

Agricultural economics is an applied social science dealing with how human choose to use technical knowledge and the scarce production resources such as land, labour, capital and management to produce food and fibre and to distribute it for consumption to various members of the society over a time (Cramer & Jensen).

Nature:

As agricultural economics is an applied social science, and is related with the allocation of scare resources (land, labour, capital and management) in farm production, processing, and consumption; it is both theoretical and applied in nature. Theoretical, because it focuses on the development of principles of resource economics, production and distribution economics. It is applied in nature as it deals with the applications of these principles to production, consumption and distribution activities in agriculture. These principles have emerged from the basic principles in economics as discussed above.

Scope:

The scope of agricultural economics can be summarized precisely as follows –

a. Agricultural economics deals with the relationship between different enterprises indicating choice of farming as an occupation and also between different streams or branches of farming, for example cultivation of crops, raising livestock, fisheries, poultry etc. or even between various crops.

b. The optimum choice between the factors of production (example: how much should labour and capital be combined to produce a certain output) to maximize profit and reduce costs.

c. Cost-benefit relationship or the relationship between factors of production and price

d. Commercial relationships of farmers with the national and global markets

It is very important to know that agricultural economics as is applied branch, so it does not differ much from general economics. All tools that are used in general economics are also used in agricultural economics specialized towards agricultural goods and services.

20.4 CHARACTERISTICS OF INDIAN AGRICULTURE AS AN INDUSTRY, ROLE IN THE NATIONAL ECONOMY

- Indian agriculture sector is the primary sector of the economy that contributes around 18% (2nd advanced estimates of National Income 2022-23) to the national income and engages more than 55 per cent of the national population as workforce.

- India is one of the major agricultural players, globally and is one of the largest producers of many agricultural commodities. It is global leader in milk, pulses, and spices production, is second largest producer of wheat, rice, cotton, sugar, fruits, vegetable, and tea. For the year 2022-23, India's estimated production of food grains is 330.53 million tons as per 3rd advanced estimates of food grains released by the Ministry of Agriculture and Farmers Welfare and horticulture production is 351.92 million tons. Dairy is a fast-emerging sector in India. Milk production was 221 million tons in 2021-22, and poultry is a fast-growing sector in India. Today the combined gross value added by wheat and rice is lesser than the gross value added by the Milk alone.

- Agriculture provides raw material to the food processing industry which is poised for a larger growth year on year basis, indicating that the agriculture sector will tend to grow in the coming years. However, there are challenges. According to the last Agricultural Census held in 2015-16, the average land holding in India is 1.08 hectare which is continuously declining posing several challenges like use of advanced technologies on farm. Mechanisation is increasing, still the investment in the sector is low and that prevents gross capital formation hampering long term growth and development.

Based on area of land, a landholding can be classified as

Less than 1 ha = marginal land

1 to 2 ha = small

2 to 4 ha = semi-medium

4 to 10 ha = medium

Above 10 ha = large holding

Further 1 hectare or 1 ha = 2.47 acre and 1 acre = 4046 m^2 (square meter)

Notes

- The average household farm income as per the survey conducted by the National Sample Survey Organization (NSSO) in 2019 is only Rs 10, 218 per month (increased from Rs 6446 per month as per previous survey conducted in 2014). The income is not just from crops, it also includes incomes from livestock, and income from off farm and non-farm sources (wages and salaries). Low incomes have prevented young skilled workforce to engage in agriculture. Many want to leave farming. In search of jobs and better resources, many migrate from less developed regions to more developed places for work. This results in the shortage of labour also hampering farm activities in the states from where large-scale migration happens.

- Therefore Government of India formed an Inter-Ministerial Committee under the chairmanship of Dr. Ashok Dalwai, then Additional Secretary to the Government of India, to double farmers' income in 2016, the committee submitted its report in 2018 giving more than 500 recommendations for enhancing yield, and production, building logistics and infrastructure for better marketing, introducing marketing reforms and space for new marketing institutions. The committee suggested improving resource use efficiencies like irrigation, seed and fertilizers, use of digital technologies and stronger extension services. Many recommendations have been put in place; biggest and most revolutionary being the Farmers Producers Organizations (FPO), digital agriculture, start-ups etc.

- Indian agriculture is also highly dependent on South West Monsoon. The changing climatic conditions have brought bigger challenges to the removal of hunger and poverty as part of Sustainable Development Goals (SDGs) 2030. India needs to make huge budget allocation in research and development in agriculture sector.

ACTIVITY 2

Visit a vegetable market. Try to purchase some vegetables. Notice and write the factors that affected your decision to purchase from a certain retailer.

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20.5 DEMAND AND SUPPLY

20.5.1 Demand

Demand is your ability and willingness to buy a certain quantity of good at a certain price, other things being constant. Willingness means you have the desire to buy the product and ability means you can afford to pay for it. Until you have these two, you cannot create demand for any good or service. **The law of demand** states that a quantity demanded of a good and service during a given period relates inversely to its price, considering other factors remain constant.

If the price of good x is P_x and quantity demanded is Q_x, then according to the law of demand

$$Q_x=1/P_x$$

As the relationship is inverse by nature, when price increases, quantity demanded decreases, and when price decreases, quantity demanded increases.

The nature of the demand curve is therefore downward sloping and it is due to two effects

a) **Substitution effect**: As many wants to chase few resources, which increases the price of a good, then consumers substitute that good with relatively cheaper goods, and the quantity demanded of the cheaper goods increases (and vice versa). For example, you might consider replacing a costly pulse with a relatively cheaper one. If you do so, you will notice that the demand for the cheaper product rises while that of the costlier one decreases. Therefore, price and quantity demanded are negatively related to each other and the curve is downward sloping.

b) **Income effect:** Income is of two types: money income, which is simply the total money a person receives, and real income, which refers to the purchasing power of the money earned. A fall in the price of a good increases consumers' real income, making them able to purchase more goods. For a normal good, this leads to an increase in the quantity demanded.

The movement along the demand curve is caused only by the change in price. In figure 20.1 below as the price decreases from P_A to P_B the quantity demanded increases from Q_A to Q_B. This is known as movement along the demand curve.

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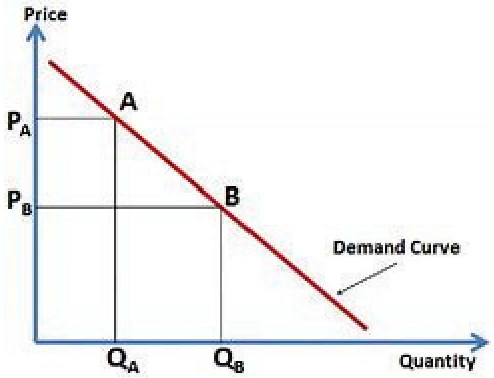

Fig. 20.1: Movement along the demand curve

Exceptions to the law of demand

There are certain exceptions to the law of demand where the inverse relationship between quantity demanded and price does not fit. These are

a. For prestigious or luxury goods such as diamonds and BMW cars people prefer to purchase them at high prices. These items are typically bought by high-income individuals for whom prestige and luxury are important. An increase in the price of these items may even lead them to spend more, as the more expensive the possession, the greater the prestige one has in society.

b. For necessary goods also, demand rises despite price rise. You will not stop consuming milk or reading the newspaper every morning. While milk prices have increased, people have not stopped consuming it. So the items of necessity do not follow the law of demand.

c. Giffen goods do not follow the law of demand. They were named after a Scottish economist, statistician, and journalist named Robert Giffen in the late 19th century. These goods are low-income non-luxury items that have very few substitutes available in the market. As these goods are low-income or inferior, and do not have close substitutes, their demand does not decrease despite an increase in price. For example, bread can become a Giffen good during a war when there is no substitute. Although it may be an inferior good during normal times (when you might prefer to have pasta instead), the demand for bread increases during a war, and people will line up for it. Even if the price increases, demand will not decrease as there is no close substitute available.

Demand and the quantity demanded: It is very important to understand the difference between the demand and quantity demanded of a good. The change in the quantity demanded happens only when there is a change in price and it is represented by the movement along the demand curve as above (Fig. 20.1), the change in demand happens

Notes

due to the factors affecting demand i.e., income, price of substitutes, tastes, preferences, consumer expectations. In such cases whole demand curve shifts either upward or downward. An upward shift in the demand is known as increase in demand, while the downward shift indicates the opposite of it (decrease in demand).

Quantity demanded is reflected by movement along the demand curve, demand is reflected by movement of the demand curve. This is very important and shall be understood very carefully.

Factors affecting demand/ shifts in the demand curve: A demand curve indicates the relation between prices of a good and quantities demanded when other factors that could affect demand remain unchanged. These factors are also called determinants and are as follows

- Changes in income of consumer
- Changes in prices of substitute goods or complements
- Changes in expectations of consumers
- Changes in the number or composition of consumers
- Changes in tastes of consumers

The change in these determinants results in a change in the demand. At every price, different quantity is demanded, and so the entire demand curve is shifted either up or down (Fig. 20.2). This is known as movement of the demand curve and is possible only when the determinants change.

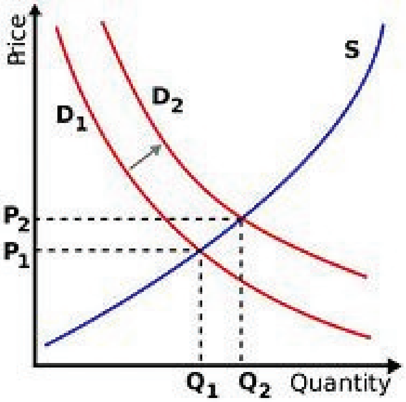

Fig. 20.2: Shift in Demand Curve (Change in demand)

Change in demand: When the demand increases, at each and every price, more of the good is demanded. The demand curve hence shifts to the right. In the following sections, we will discuss the shift in the demand curve and factors affecting these shifts.

Notes

a. **Change in consumer income**: The goods are classified into two categories- Normal good and Inferior good, depending on the response for their demand to the change in consumer income.

A good is said to be normal when its demand increases when consumer income increases. An increase in income shifts the demand curve to the right means more of the good is demanded at each and every price. An increase in income will raise the demand for air conditioners.

An inferior good is a good whose demand increases as consumer income falls. For example, demand for public transport increases when income falls.

b. Change in price of related goods: Related goods are of two types

I. **Substitutes:** These can be substituted for each other and cannot be consumed together. For example, wheat and maize, Pepsi and Coca-Cola. These goods are related in a way that an increase in the price of one shifts the demand curve for the other rightward. If the price of wheat rises, people tend to shift to a close substitute, such as maize, and therefore the demand for maize increases. The reverse also holds true. A decrease in the price of Coca-Cola leads to a decrease in the demand for Pepsi, simply because people demand more Coca-Cola at low prices.

II. **Complements:** Complementary goods are always consumed or utilized together, for example, a car and fuel, bread and butter. Therefore, when the price of a car increases, the demand for cars goes down, and as a result, the demand for fuel also decreases. This is because an increase in the price of one complement leads to a decline in the demand for the other. Similarly, when the price of bread decreases, there is a greater demand for butter because the low price of bread increases the demand for it, and since bread and butter are consumed together, the demand for butter also increases.

c. Change in consumer expectations: Consumers expectations also change the demand. When they expect price to rise in the future, demand for the goods increases today. For example, if you expect that price of onion will shoot to Rs 150 per Kg tomorrow as against only Rs 50 today, your demand for onion will increase today. Opposite of it happens when consumer expects that prices will decline in the future. In that case demand slows down today.

d. **Changes in consumer taste:** A change in taste of consumers creates altogether a new demand. For example, if you have developed a taste for momos, and many more like you, then the signal that goes to the momo maker is that more demand has come at all prices that he or she is offering for the product.

e. **Changes in composition and number of consumers:** If there is a rise in population, demand for food will increase. If only vegetarian population increases, demand for fruits and vegetables will increase more than demand for meat and eggs.

ACTIVITY 3

Creation of demand is not easy. Try to sell a pen to your friend. See if you could convince him to purchase it. What did you do to convince him? How did you create the demand for this pen that you just sold? Share your experience.

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20.5.2 Supply

A supply is from the side of the producer. Supply refers to the relation between the price of a good and the quantity that the producers are willing and able to offer for sale during a given period, while other things are constant.

The law of supply states that the quantity of a good supplied during a given period is usually directly related to the price of the good. Increase in price leads to increase in quantity supplied and vice versa. The Supply curve is therefore upward sloping (Fig. 20.3)

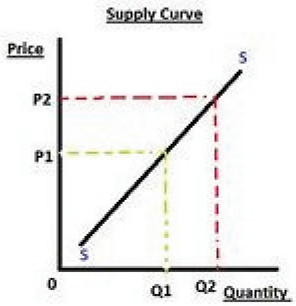

Fig. 20.3: Supply curve

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Like demand, movement of supply curve is caused by the change in . In that event it is known as change in quantity supplied (Fig. 20.4)

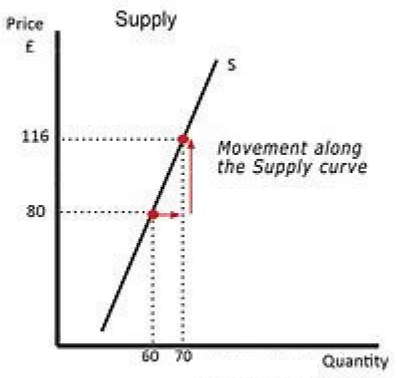

Fig. 20.4: Movement along the Supply Curve

Factors affecting supply cause movement of the supply curve

For the change of supply or movement of supply curve, following factors are involved. These factors are

a. Technological changes

b. Changes in prices of relevant resources

c. A change in price of alternative goods

d. Changes in expectations of producers

e. Changes in the number of producers or suppliers

Changes in supply therefore are caused by changes in the factors or determinants to the supply curve. It results in changes to the relationship between the price and quantity supplied, and at each and every price, a different quantity is supplied. As a result, we get a new supply curve

A. Technological changes

Technology is the economy's stock of knowledge about how to combine resources efficiently. It is easy to supply more when one has an effective technology. For example, you can produce more with high yielding varieties of seeds (which is an improved technology) as compared to low yielding ones. Improvement in technology shifts supply curve right and degradation of technology reduces supply at all prices. Several researches have shown that using Micro Irrigation Techniques (sprinkler or drip irrigation) over conventional technique (flood irrigation) has improved the yield of the crop.

B. Changes in price of relevant sources

When the price of resources increases, it becomes difficult to procure those resources and combine them efficiently to produce goods. Supply increases when raw materials are available at cheaper rates. For example, if seeds, fertilizers, and labour become more expensive, it will be difficult for the farmer to purchase them and produce crops. When production decreases, supply will also decrease. The opposite is true when resources or raw materials become less expensive.

C. A change in price of alternative goods

Let us begin with an example. If the price of meat increases, producers of meat will supply more meat at all prices. As they increase the supply of meat, the supply of leather will also increase. How is this possible? It is possible because when animals are culled for meat purposes, their hides and skins are removed and utilized by the leather and other industries to produce leather and other products. Hence, high meat prices promote meat producers to supply more meat in the market, which leads to more culling and more availability of leather.

D. Changes in expectations of producers

If producers expect that the prices of resources used in the production process will rise in the future, they will supply less in the future (as the cost of production will rise), so the supply curve will shift downwards. If the expectation is the opposite, the supply curve will move upwards.

E. Changes in the number of producers or suppliers

It simply means that when the number of producers increases, generally the supply also increases, assuming other things remain constant. For instance, if there are more chocolate manufacturers, we can expect the supply of chocolates to increase in the market. Right? I hope you can relate to many such items.

INTEXT QUESTIONS 20.2

1. Movement of demand and supply curve is caused by ....
2. Movement along the demand and supply curve is due to ....
3. When price rise, other things constant, quantity demanded ....
4. Bread and Jam are...........................goods.

5. Wheat and Maize are……………………goods.

6. Goods that do not obey law of demand are called …………………goods.

20.6 PRICE DETERMINATION

Notes

Prices are determined by the interaction of demand and supply forces. At higher prices, sellers are interested in supplying, but at lower prices, buyers are interested in buying. Both these forces interact with each other until there is an agreement on a price between sellers and buyers to sell and to buy, respectively. When this happens, the trade is executed, meaning the commodity is exchanged between the buyer and the seller, and the transaction is settled in cash. The buyer pays cash (the settled price, equilibrium price, or market clearing price) to the seller, and the seller transfers the commodity to the buyer. This market equilibrium is expressed in fig. 20.5. The figure expresses the price of talcum powder and the quantity demanded of the commodity. E is the equilibrium price arrived at by the interaction of demand and supply forces. At higher prices producers are willing to sell more and there is surplus because buyers are not willing to buy (see the quantity demanded at Rs 600 is10 units while the supply available is 70 units indicated by point A and B). When no sale happens at that high price, sellers reduce the offer price and at E i.e., Rs 300, they find buyers to purchase talcum powder. At any point below E, example at Rs 100, you would see that buyers are willing to buy but sellers don't offer the product. Hence buyers relax themselves and get willing to purchase at a higher price. At low price there is shortage in the market, because sellers don't supply. The pressure again keeps the price back to point E. At E, you would see that both parties agree to trade (buy and sell).

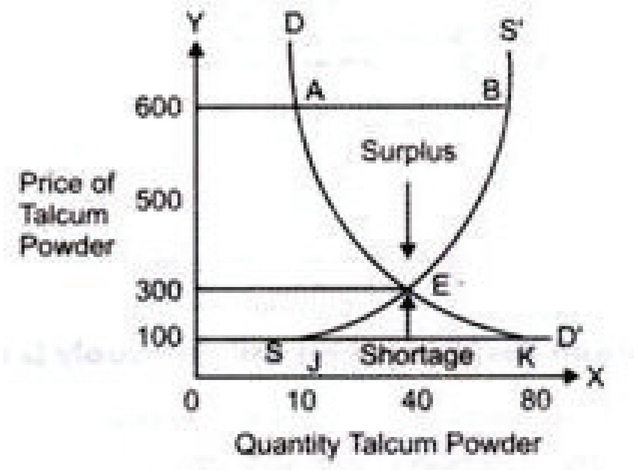

Fig. 20.5: Market Equilibrium example

INTEXT QUESTIONS 20.3

1. Price of a product determined by the interaction of demand and supply forces of market is termed as ....

2. If a product is available at higher price than equilibrium price, market receives surplus (True/False).

3. At lower price, demand is ....

20.7 FACTORS OF PRODUCTION

The major factors of production are land, labour, capital and management. The technical relationship of these factors is termed as production function. These four factors come together to produce crops and livestock goods and services. Land is the resource you all are aware. Without land, where will you grow? Labour is another crucial factor. It is the human effort that goes in the process of production. It could be a farmer's owned human labour which is known as family labour or could be hired. It is important to know that the labour could be of two kinds. One is just related to the number of humans engaged in the process of production, the other is efficiency of labour which is related to skills the humans have, also known as human capital. Acquiring of skills by workers is known as acquiring human capital. If the amount of human capital by workers can be raised, it will bring more efficiency in production.

Capital is the third factor of production. But what is capital? You might be wondering that any resource is called capital if it satisfies two conditions. i.e., 1. the resource must have been produced and 2. the resource should have the ability to produce other goods and services. One thing that is not considered capital is money. A firm cannot use money directly to produce other goods but it can certainly be used in acquiring capital which can then be utilized by human labor to produce a good or a service. For example, money cannot be grown on land. But from money, you can purchase capital like seeds, fertilizers, machinery, tools etc. which can be combined in different proportions by human efforts (labour) on a certain piece of land to yield a certain output of the crop. Management efforts help in combining all other resources well. A bad management has negative impact on yield and incomes. Hence management is considered fourth factor of production.

Budget in hand is always a limiting resource in combination of inputs or outputs. As a consumer we often think to make decisions of choosing among several commodities,

Notes

but we are constrained by the budget. Consumer makes rational decisions by combining the more number of low priced product and less of high priced product.

20.8 ELEMENTS OF COSTS AND BENEFITS WITH EXAMPLES

20.8.1 Short run and long run costs

In economics, **short run** refers to the time period of production when at least one of the resources or factors of production is fixed and cannot be changed. In short run, a firm can only change its variable resources. **Variable resources** are those that can change with the level of output. Examples of variable resources are seed, fertilizers, plant protection chemicals, manures, hired labour, etc. In short run therefore, a firm can change its level of production by changing its variable resources only. The costs incurred in short run are known as **short run costs**. It means that short run has both fixed and variable costs.

20.8.2 Long run Costs

It is easy for a firm to adjust its fixed and variable factors and hence it has more flexibility in adapting to changing conditions. For example, with changing climatic conditions, no new technology can be adapted in short run because technology development and adoption takes time. However in long run, technology development and adoption is feasible and hence in long run it becomes easy to expand size of firm. One can add more land in long run. The costs associated with these resources are known as long run costs.

20.8.3 Let us now understand fixed and variable costs

Fixed Costs: These are costs that do not change with the level of production, and have to be incurred by the producer irrespective of the increase or decrease in output. For example, land is a fixed resource and remains unchanged regardless of the crop yield. The cost of land is fixed, irrespective of the output a farmer gets from it. Similarly, if the land belongs to somebody else, the farmer has to pay rent, which remains constant regardless of the level of output. Machinery costs are also fixed and cannot be divided to produce less. Therefore, fixed costs are incurred at once in the production system.

Variable costs: These costs vary with the level of output. 1 kg of seed yields 100 kg of crop. To produce 200 kg of crop, one will need 2 kg of seed and hence shall pay for 2 kg. So, the cost of raw materials like seed, fertilizers, pesticides, manure, irrigation and labour cost of weeding, harvesting, ploughing are common variable costs incurred by a farmer in the production of crops.

Total costs: Fixed costs and variable costs together form the total costs incurred by a farmer.

Cost of Production: If the total cost is expressed in terms of the unit quantity produced, it is known as cost of production. Examples include rupees per kilogram (Rs./kg) or rupees per quintal (Rs./q) or rupees per ton (Rs./t).

Cost of Cultivation: If the total costs are expressed in terms of area under cultivation (Rs. per acre or Rs. per hectare), it is referred to as cost of cultivation (as you have cultivated an area under that crop).

An illustration of Cost of Production and Cost of Cultivation: For example, if you have incurred Rs. 10,000 to cultivate one acre of any crop then your cost of cultivation is Rs. 10,000 per acre. Now let us assume that from one acre of this crop, you received 100 Kg of the product then your cost of production will be Rs. 10,000/100 Kg. Right? If I wish to convert it into Rs. /Kg then it can be expressed as Rs. 100 per Kg. It means that from one acre if you are producing 100 kg of a crop, your cost of production per kg is Rs. 100 per Kg and your cost of cultivation per acre is Rs. 10,000 per acre. Hope you understood the difference between the cost of cultivation and cost of production.

There are also concepts of average costs and marginal costs

Average cost: This is the cost incurred per unit of output. It is expressed as

Average cost (AC) = Total cost/Quantity

Marginal cost: It is defined as the change in total cost with respect to the change in the total quantity produced.

Marginal cost (MC) = Change in the total cost/Change in the total quantity

Total or returns: Returns are the receipts generated from the sale of the produce. These are the product of the quantity sold in the market and the sales price.

Gross returns or total returns = Total output sold in the market x Sales price

Net returns: The net receipts generated after meeting the costs incurred are known as net returns.

Net returns = Gross returns - Gross or total costs

Net returns over variable costs = Gross returns - Variable costs

Net returns over fixed costs = Gross returns - Fixed costs

Notes

ACTIVITY 4

Meet a farmer in your locality. Ask him about his area of cultivation and the costs that he incurred for growing the crop in that season and convert it into per hectare (remember, 1 hectare = 2.47 acre). Please ask the fixed and variable costs both. Then enquire about his yield and price at which he sold the crop. Try to calculate the cost of cultivation of that crop. Find Net returns.

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WHAT YOU HAVE LEARNT

- Individuals face trade-offs while making decisions.
- The cost of sacrificing something to get some other thing is known as Opportunity cost.
- Rational people weigh marginal benefits and marginal costs.
- In case of a market failure, Government can improve the market outcome.
- Trade makes everybody better off and is the engine of any economy.
- If money grows in circularity, inflation rises.
- More productive a nation, better is its standard of living.
- Society faces a short-run trade off between inflation and unemployment.
- Agricultural Economics is applied social science which is all about combination of resources to maximize agricultural production, minimize costs and make optimum profits.
- Agriculture sector in India is flourishing but has several challenges.
- Doubling or enhancing farmers' income is important.
- Technology can make lives better, but its cost should not be too high.
- Demand and Supply situations govern the economy.
- A change in quantity demanded is not a change in demand.

- Change in quantity demanded is caused by a change in price.
- Change in quantity demanded is a movement along the demand curve.
- Change in demand is caused by a change in the determinants.
- Change in demand shifts the demand curve.
- Giffen goods and luxurious goods do not follow the law of demand.
- The quantity of a good supplied is directly related to its price.
- A change in quantity supplied is caused by a change in the price of the product, leading to a movement along the supply curve.
- A change in supply is caused by changes in the determinants, resulting in a shift of the entire supply curve either upwards or downwards.
- The satisfaction which is derived from consumption of a commodity is called utility.
- The principle of utility is an important principle in decision making process, especially the Principle of Diminishing Marginal Utility.
- People are bound by the budget in hand and that leads to substitution between input of output.
- If one wants to use machinery, naturally the labour usage will be low.
- The price at which the quantity demanded to sell and buy is agreed upon by a buyer and seller is called the equilibrium price.
- Total cost is further divided into fixed and variable costs.
- Fixed costs do not change with the level of output, while variable costs do change.

TERMINAL QUESTIONS

1. What is Economics? Who is the father of economics and which book he wrote?
2. Why does the society or the individual face the problem of trade off?
3. Explain the principle of opportunity cost.
4. What is demand? How is it generated?
5. Discuss the factors affecting demand.
6. Explain the characteristics of Indian agriculture.

Notes

7. What is the Principle of Diminishing Marginal Utility? Why it is important?
8. Discuss the short run and long run costs in agricultural economics.
9. Discuss the factors of production.
10. Why is the demand curve downward sloping?
11. Discuss the different exceptions of the law of demand.
12. What are complementary goods? Give examples.
13. What are substitutes? Give examples
14. Give examples of Giffen goods?
15. What kind of relationship do supplied quantity share with the price of that product?
16. Explain the determinants of supply.
17. How market equilibrium is determined?
18. Draw a graph of market equilibrium citing an example on your own and explain the same.
19. Explain the fixed costs that a farmer incurs.
20. What are the different kinds of variable costs incurred by a farmer?

ANSWERS TO INTEXT QUESTIONS

20.1

1. Less
2. Opportunity Cost
3. Income
4. Margin
5. Inflation

20.2

1. Factors affecting demand and supply
2. Only and only Change in price

3. Low
4. Complements
5. Substitutes
6. Giffen goods

20.3

1. Clearing Price
2. Surplus
3. Low

GLOSSARY

Economics: It is the study of choice under conditions of scarcity.

Agricultural economics: It is a branch of economics which studies how scarce resources like land, labour, capital or management can be used efficiently for better agricultural production and distribution to consumer.

Demand: Demand is ability and willingness of a person to buy a certain quantity of good at a certain price.

Supply: Supply is ability and willingness of a seller to provide a certain quantity of good to buyers.

Fixed cost: These are the costs which do not change with the level of production. E.g., cost of land, machinery or farm buildings.

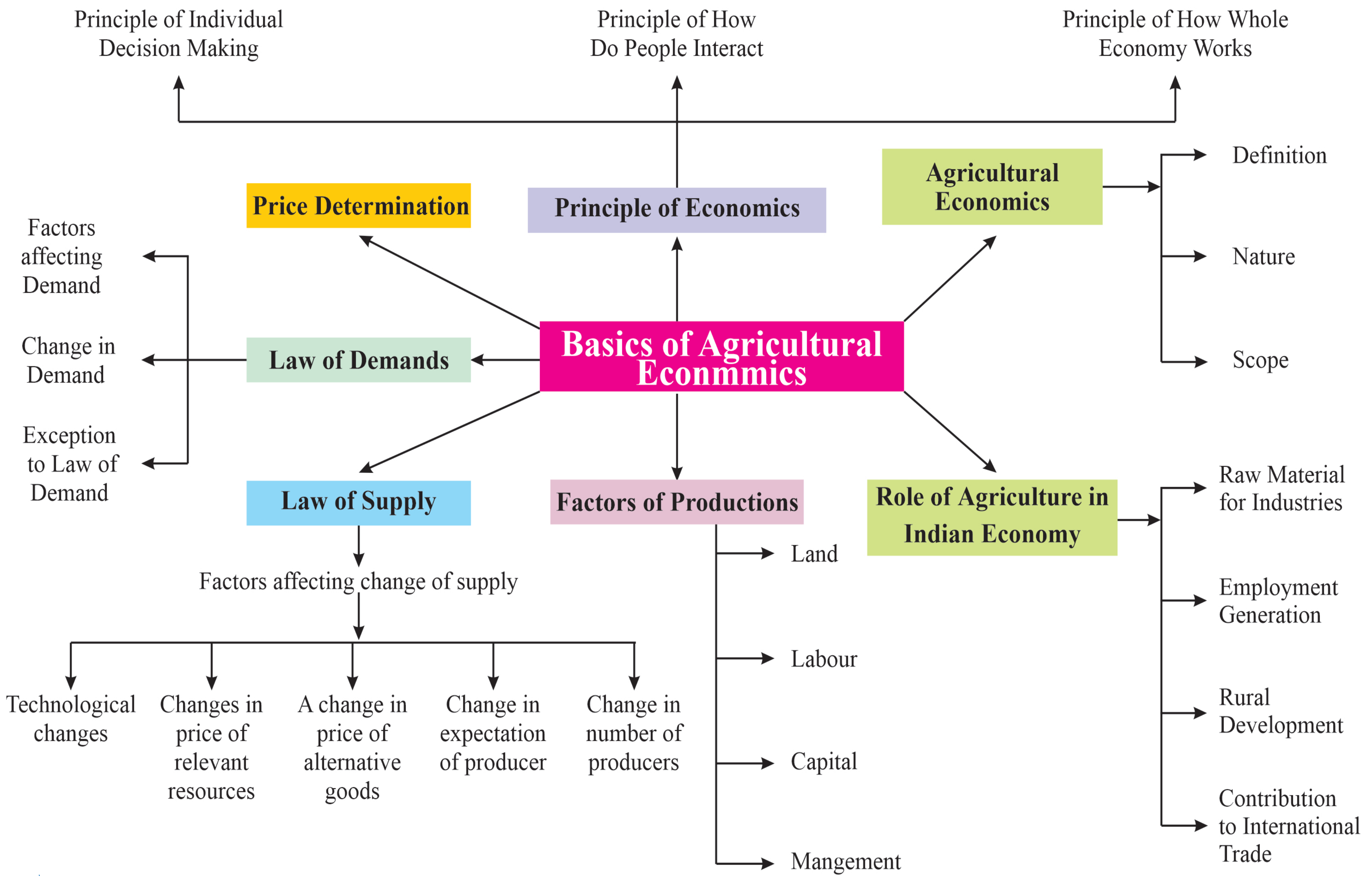
Variable cost: These are the costs which vary with how much a farmer produces or sells. Examples for such costs are cost of seeds, pesticides or fertilizer.

SUGGESTED READINGS

Hand Book of Agriculture, Published by Indian Council of Agricultural Research (ICAR), New Delhi.

Singh, A., Sandhu, A. N. and Singh, J. (2014). Fundamentals of Agricultural Economics, Himalaya Publishing House, New Delhi.

WHAT YOU HAVE LEARNT



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AGRICULTURAL MARKETING AND POLICY

While the crops are produced in the fields, they move from producers to consumers to finally reach in their plates. Ever wondered what it takes to make the products reach from field to plate? Now as you know what is demand and supply and their interaction at equilibrium prices causes exchange, you should also know how a product reaches the stage of the exchange. The market is a place where exchange happens. It could be a physical or virtual market. All that needed is a buyer, a seller, the good and the medium of exchange, i.e. money. However in olden days medium of exchange was goods which was called barter system. The activities that facilitate the exchange are known as marketing activities. Marketing leads to the execution of trade and is one of the most important set of activities. In this lesson you will learn about marketing and the institutions engaged in the marketing of agricultural commodities in India. You shall also learn about the important policies of the Government of India to facilitate the marketing of agricultural goods.

LEARNING OUTCOMES

After studying this lesson, the learner:

- explains the concepts of agricultural marketing;
- identifies marketing channels;
- describes marketing functions;
- recognizes different marketing institutions and their role; and
- discusses Government policies to facilitate the marketing of agricultural goods.

Notes

21.1 AGRICULTURAL MARKETING

'Market' is a word that originated from the Latin word 'Marcatus' which means merchandise. It is related to a place where trade or business is conducted. To be considered a 'market,' a place must satisfy the following conditions.

1. It must have defined boundaries when it is physical. In e-commerce, the concept of boundaries dilutes.

2. There must be a commodity or a good for which the transaction will be carried out.

3. As the transaction happens (money for a commodity), there must also be buyers and sellers.

4. These buyers and sellers must interact with each other to arrive at equilibrium prices so that the transaction is settled.

Marketing creates time, place, form, and possession utility through various activities. Thomson suggested that agricultural marketing includes the study of all activities that facilitate the movement of goods from one end to another, as well as the agencies responsible for these activities. These activities create time, place, form, possession, and information utility for consumers. It is important to note that marketing ultimately leads to trade (exchange between a buyer and a seller).

21.2 UTILITY IN MARKETING

Demand is generated when there is utility. What is utility then? Utility simply means value and the customer or consumer wants value for money. If something does not generate utility or value or satisfaction for you, you will not spend the money on it or will not have any demand for it. Right? This utility is generated through five ways of marketing.

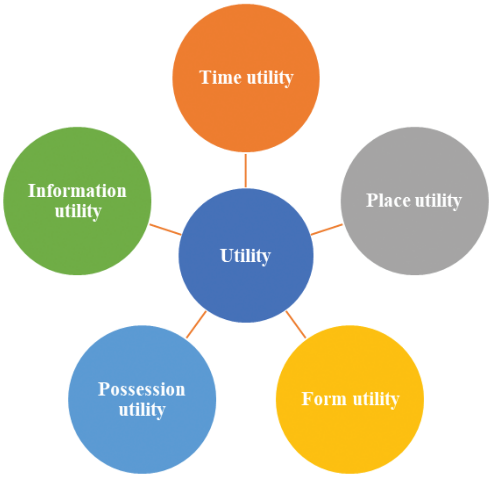

Fig. 21.1: Types of utility

21.2.1 Time utility:

It addresses the question of 'When'? Is a commodity or good available when a consumer wants it? In other words, do you have a supply when the demand is raised? Only then does the commodity have value. What is the use of supplying woollens in summer? Nobody will purchase it, right? The consumer is willing to pay for any product when it is available at a desired time. The demand for cold drinks decreases in winter, so it is wise to produce less during winter. Crops are seasonal, and potatoes, for example, are demanded throughout the year but produced during only three to four months. To meet the demand in the off-season, potatoes are stored in cold storage. Storage ensures that potatoes are supplied to the population whenever there is a demand. Hence, people are willing to pay for potatoes. This is known as the creation of time utility. Storage adds value in terms of time. If you understand the demand of consumers and their timely needs, you will be able to create utility; otherwise, there will be no demand for your product.

21.2.2 Place utility:

It addresses the question, 'Where do you need the goods or commodity'? Place utility refers to the activities that add value in terms of the availability of a product at a desired place. If you need mangoes in your location but they are not available, it will not help your business to grow. Transportation and logistics are the marketing activities that create place utility for consumers. Somebody who wants to provide mangoes at a desired place can create value by transporting them. Similarly, take the example of input service providers. If you purchase pesticides, seeds, or a tractor, some companies provide after-sales support or technical support in the field. Farmers prefer companies that provide such support services at a desired place, which is the field or farm for them. Online marketing, such as Amazon, is popular because you get timely deliveries right at your doorstep. Hence, place utility is created.

21.2.3 Form utility:

When value is added for the consumer by changing a good into a desirable form, demand for related products may increase. For example, if people demand pizza, the demand for cheese will increase. However, cheese is a processed form of milk, which adds value to milk. Processing creates form utility for the customer. Similarly, understanding what the consumer wants and serving the good in that form generates demand, known as form utility. Processing is therefore an activity in marketing that creates form utility for the consumer.

21.2.4 Possession utility:

A consumer shall be able to use a good immediately after its possession. Even if you possess something but are not able to utilize it, how can you achieve possession utility? So, possession of anything is useful if it creates a utility for you. For example, if you don't get (possess) money in time (loan/finance), will you be able to purchase the product without it? This happens with the farmer. When farmers don't have money, they would want the loan to carry on their farm operations. For the said purpose, they might want to go to the bank, but they don't take it from bank for several reasons, one of them could be a delay in disbursement of loan from the bank. So, the farmer would go to the middleman or a local trader for an advance and as that money or advance is instant, it creates possession utility for the farmer. The farmer can utilize it immediately for farm operations or other needs. Timely finance thus creates possession utility.

21.2.5 Information utility:

Latest to the list of utilities and not to be missed is information utility. If you have information, you will be able to take timely decisions, otherwise it is not possible in the absence of information. This era itself is known as the era of information technology. Digital connect has made information reach faster to the customer creating value for even new products and services in the market. Hence we can say that digitalization has created information utility for the farmer as timely and right information helps the farmer in taking many decisions related to crop production and marketing in time efficient manner.

INTEXT QUESTIONS 21.1

1. The term market is derived from a Latin word..............

2. Demand is generated when there is ....

3. Agricultural crops are..................................in nature.

4. Transportation creates

   a. Information utility b. Place utility

   c. Time utility d. Possession utility

5. .... creates form utility.

21.3 MARKETING CHANNELS

Have you ever wondered how apples from a far orchard in Himachal reach the vendor in your street or the market? The goods move from the point of production to the point of consumption through different channels or routes and in this process, number of stakeholders are involved. These routes are known as marketing channels.

Generally, a contractor can buy the orchard and arrange for the picking and transportation of apples. The apples are picked on the farm and then sorted according to size, adding value to the apples on the farm. They are then properly arranged in crates and stacked neatly on trucks. Transportation adds utility to the apples, ensuring that they reach the right place at the right time, with no spoilage and uncompromised quality. The truck then reaches the cold storage or the wholesaler in the market. The processor can buy apples from cold storage or the wholesale market and use them for manufacturing apple juice. The apple juice is then packed under the brand name (for example, Swastham) and goes to retailers (supermarkets or retail stores in your location). Raw apples from wholesalers are also purchased by retailers, and then some small vendors purchase them from retailers to sell across streets and other markets. Finally, you or your family purchase and relish its taste. Thus, you can see that many intermediaries are involved in getting apples to reach you from markets. There are two routes or channels that you would have noted in the above discussion:

1. Channel I: Farmer → aggregator → cold storage → processor → retailer → consumer
2. Channel II: Farmer → aggregator → cold storage → wholesaler → retailer → consumer

There may be other routes also when there is no aggregator and cold storage

3. Channel III: Farmer → Wholesaler → Retailer → Consumer
4. Channel IV: Farmer → Wholesaler → Exporter
5. Channel V: Farmer → Retailer → Consumer

Every channel delivers the product to the final consumer. In case of cereals, the Food Corporation of India is engaged in procuring and distributing them through fair-price shops. Hence, one of the channels for rice and wheat (through the fair-price shops) is

Farmer → Food Corporation of India → Fair Price Shop → Consumer

If a village trade is involved, then the channel becomes

Farmer → Village trader → Wholesaler → Retailer → Consumer

Rice and pulses go through the millers to finally reach retailers and consumers. Thus millers are important in pulses and rice distribution channels.

A marketing channel is the chain of intermediaries through whom the various food grains pass from producers to consumers. Kohls and Uhl (2002) defined marketing channels as alternative routes through which the product flows from producers to consumers.

There are several factors that affect the length of marketing channels. If a product is perishable by nature, the length of the channel must be short, for example, fruits are harvested from the farmer's field and then are quickly transported to the point of consumption with less number of middlemen. Cereals, on the other hand, are picked from the field, then go to the processor, wholesaler, retailer, and consumer. In case of cereals and millers, processors are added to the channel. In case of oilseeds, we have oil extractors in the channel. The nature of the end product decides the length of the channel. If one wants to consume raw, channel will be short, with refined or processed form of the same product, the length will increase. Small units are sold through retailer; bulk is sold through wholesalers. Sometimes, neither wholesaler, nor retailer is involved; the product is directly sold to the consumers, like in Farmers' markets where one can directly purchase from the growers.

INTEXT QUESTIONS 21.2

1. Cereals have.......................... marketing channel than fruits.
2. Where does the consumer directly purchase product from the growers?
3. Why marketing channels are existing in agriculture market?

21.4 MARKETING FUNCTIONARIES

Following are the marketing functionaries involved in the marketing of the agricultural produce

21.4.1 Producers:

Producers, also known as farmers, are the first functionaries. Farmers perform important marketing functions like, grading, sorting, and cleaning, among others. They also sell

their produce in village or local markets. Farmers who are big and have relatively large produce to handle also perform the function of transporting the produce to distant markets and selling it to wholesalers in cities. Direct selling to wholesalers or large buyers in the cities helps farmers to earn profits.

21.4.2 Middlemen:

Middlemen perform various marketing functions and add value to the produce. However, redundant middlemen who do not add any value to the commodity ecosystem are not desirable. They can be classified as follows:

A. **Merchant middlemen:** They hold the title of the goods and sell or buy them on their own. Further, the merchant middlemen are of two kinds:

   a. **Wholesalers:** They trade in bulk. They may buy the agricultural commodities either directly from farmers or other traders (could be other wholesalers too) in the market and then sell it to the retailers either in the same market or in other markets. The functions performed by the wholesalers are:

      - Assembling the goods for consumers from different localities
      - Sorting the goods based on their quality
      - Maintaining the supply during peak and lean seasons
      - Regulate the flow of goods in various markets
      - Provide loan facilities to farmers to meet their requirements
      - They have storage facility also.

   b. **Retailers:** Wholesalers are the point of purchase for bigger buyers, for example, processors who need the commodity in bulk. But what about the small quantities or small traders? The merchant middlemen who purchase from wholesalers and then sell in small units to the consumers are called retailers. These are closest to the consumers in any marketing channel.

   c. **Itinerant traders**: These are petty merchants who purchase directly from producers. Generally, small and marginal farmers sell to itinerant traders as they don't have enough income to take the product themselves to the buyers in the markets. Itinerant traders move from one village to another and make this task easy for the farmers by purchasing the produce directly from them, transporting it to the market, and selling it there.

Notes

d. **Village merchants:** As the name suggests, they function at the village level. It is generally found that in villages, farmers take loans from local traders because they believe that institutional sources of finance (such as banks) involve a lot of paperwork and are hard to access. The easy availability of loans from non-institutional sources of finance, such as these village merchants, binds them to sell their produce only to these village merchants. The village merchants not only provide loans to the farmers, but they also supply essential goods for consumption purposes to these farmers. Another feature of this relationship is that the farmers who sell to these village merchants are poor and therefore cannot go to distant markets to sell their produce.

B. **Agent middlemen:** Agent middlemen act on the part of their clients. They neither own the produce nor hold its title. The agent middlemen provide services and have nothing to do with the buying and selling of the goods in the market. Now you must be wondering what kind of services are needed in the markets. There are several services like weighing, grading, sorting, packaging, sewing bags, loading, unloading and many more. All these services are provided by the middlemen. In lieu of the services that these agent middlemen provide, they charge the farmer. This is known as their commission or brokerage. The Agent middlemen are of two types.

a. **Commission agents or Arhatias**: A commission agent acts as a representative of either the buyer or the seller in the market and handles the product in its physical form. Their job is to connect the buyer and seller and help execute the trade. They find prospective buyers and sellers and act as a mediator between them. The agent negotiates on both parties' behalf and is also responsible for arriving at an equilibrium price agreed upon by both parties. Upon the execution of the trade, they collect money from the buyer, deduct their commission, and pay the remaining amount to the seller. In exchange for the money, they deliver the goods in physical form. In unregulated markets, the commission agent is also known as an 'arhatia,' and these are two types: Kaccha arhatia and Pacca arhatia.

Kaccha arhatia: They act on farmers' behalf. They charge interest on the loan they provide to the farmers. Alongside, they also charge commission or arhat to the farmers.

Pacca arhatia: They act on behalf of traders like oil, pulse and rice millers, cotton and jute traders etc.

In regulated markets, the commission agent is only of one type and is known as an 'A' class trader. He occupies a shop or a godown for his client and charges for the service. He provides several other chargeable facilities to his client, who could be either farmers or traders.

b. **Brokers:** Brokers are also service providers but they do not have the physical possession of the commodity. A broker brings together the buyers and the sellers, so that both parties can negotiate. For rendering this service or facilitating the negotiation between parties, brokers charge 'brokerage' which depends on the kind of services provided. In physical markets, their role is limited; however, they are essential for virtual markets.

c. **Speculative middlemen:** Speculative middlemen hold the title to goods and make profits by trading them. They have access to a lot of information related to prices, production, weather, and other factors that affect the supply and demand of commodities, which helps them in discovering prices in the market. Their role is important as they help stakeholders make informed decisions. They absorb the risk of price and production by buying at low prices, giving signals to others to buy, and selling at higher prices, giving a sell signal. They make profits on short and long-run market fluctuations and exit the market accordingly. Other stakeholders like farmers and traders simply follow them.

d. **Facilitative middlemen**: As the name suggests, these middlemen shall make marketing easy. Yes, you understood it right. Facilitative middlemen facilitate various marketing sub-activities and charge fee against rendering them. These middlemen are:

   i. **Hamals or labourers:** They perform the loading and unloading of commodities on trucks or other transport means. They also assist in weighing bags in the market and also perform functions like, cleaning, sorting, refilling and stitching of bags. The fee that they charge is commonly known by the name of 'hamali'.

   ii. **Weighmen:** They weigh the commodities and are paid by the commission agents for performing the job.

   iii. **Graders:** They grade the commodity into desired grades in the market.

   iv. **Transport agency:** The agency helps in providing transport facility to move the commodity from one to another market.

v. **Communication agency:** It communicates the prevailing prices and quantity available in any market.

vi. **Advertising agency:** It is engaged in advertising about the product and its quality via different modes like newspapers, radio etc.

vii. **Auctioneers**: They help in putting up the produce for auction purpose and inviting bids.

viii. **e-marketing:** They help in selling the products online.

Marketing functionaries	Nature of work
Producer	Person who produces the product.
Wholesaler	Person who buys the produce from producer and add services to it. For this service, he charges a price before further selling the product at market.
Retailer	The market functionaries who sell the produce finally to the consumer.
Middleman/Commission agent	The market functionaries who provide the facilities for marketing of the produce.
Consumer	The person who finally pays for consumption of the produce.

INTEXT QUESTIONS 21.3

1. Wholesalers trade in …………..
2. Merchant middlemen hold the …………… of the good.
3. In unregulated markets, commission agents are also known as……………….
4. Hamals are…………………….. middlemen.

21.5 MARKETING FUNCTIONS

Marketing function is defined as any single activity which is performed in moving a product from production centre to the consumers. There are several ways to classify

marketing functions.

According to Thomsen, marketing functions are classified as:

A. **Primary functions**: These include

   a. Assembling or procurement

   b. Processing

   c. Dispersion or distribution

B. **Secondary functions:** These include

   a. Grading

   b. Standardization and quality control

   c. Packing or packaging

   d. Storage and warehousing

   e. Risk management

   f. Price determination or discovery

   g. Dissemination of market information

   h. Transportation

   i. Buying and selling

   j. Financing

C. **Tertiary functions:** These include

   a. Banking

   b. Supply of energy

   c. Electricity

   d. Communications – posts & telegraphs

   e. Market information

Further the marketing functions are classified in following way[1]:

A. Physical functions: These include

a. Grading

b. Storage and warehousing

c. Transportation

d. Processing

B. Exchange functions: These include

a. Selling

b. Buying

C. Facilitative functions: These include

a. Financing

b. Risk taking

c. Standardization of grades

d. Dissemination of market information

Another classification of marketing functions[2] is given in following way:

A. Physical movement functions: These include

a. Grading

b. Packing

c. Storage

d. Transportation

e. Distribution

B. Ownership movement functions: These include

a. Determining need

b. Creating demand

c. Finding buyers and sellers

d. Negotiation of price

e. Rendering advice

f. Transferring the title to goods

C. Market management functions: These include

a. Financing

b. Accounting

c. Securing information

d. Formulating policies

e. Providing organization supervision

Notes

INTEXT QUESTIONS 21.4

1. Banking is ……………….. function of marketing.

2. Give two examples of exchange functions.

3. Which of the following comes under primary function of marketing?

   a. Banking

   b. Processing

   c. Communication

   d. Risk management

ACTIVITY 1

Visit to a grain market or APMC market in your area and know about participants in the market and what do they do. Try to find out their margins. Don't you wonder why they are richer than your farmers?

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21.6 MARKETING INSTITUTIONS

Marketing institutions have a greater role to play in agricultural marketing. Marketing institutions means all government and private bodies including farmer and trader bodies which are involved in marketing functions. Marketing institutions give way to:

- Framing rules and regulations to facilitate trade
- Establishing organizations to perform certain marketing functions
- Establishing market infrastructure like storage, warehousing, grading and standardization facilities, and quality control labs, etc.
- Administering government policy and programmes
- Regulating demand and supply through various measures

21.6.1 Public sector marketing institutions:

- **Directorate of Marketing and Inspection (DMI), Faridabad**

  It was established in 1935 to implement the policies and programs of marketing of agriculture and allied produce in the country.

- **Commission for Agricultural Costs and Prices (CACP)**

  Established in 1965, CACP recommends two set of prices – Minimum Support Prices and procurement price.

- **Food Corporation of India (FCI)**

  Established in 1965, FCI is involved in maintaining buffer storage and distribution of food grains across the country at affordable prices to the needy population.

- **Jute Corporation of India (JCI)**

  Headquartered in Kolkata and set up in 1971, JCI works for the betterment of the jute cultivators, especially getting them access to the Minimum Support Prices for Jute.

- **Cotton Corporation of India (CCI)**

  It was established in 1970 under Companies Act 1956. It is headquartered in Mumbai and engaged in trade, procurement and export of cotton.

- **Tea Board**

  It was established under Tea Act 1953 and advances loan and subsidies to tea

growers for extension, planting, and replanting of tea gardens. It also promotes export, market intelligence, and participation of tea growers in fairs, exhibitions etc.

Notes

- **Coffee Board**

  It was set up on December 21, 1940 under Coffee Market Expansion Act. It is located in Coorg, Karnataka and engaged in promotion of sales and consumption of Indian coffee in India and rest of the World.

- **Spices Board**

  It was established in 1987 at Cochin, Kerala under Spices Board Act 1986. The Board looks after more than 50 crops, their quality production and exports.

- **Rubber Board**

  It was established under Rubber Board Act 1947, in Kottayam, Kerala. The Rubber Board conducts research and training programmes to promote production of Rubber. The board also markets the rubber and provides extension services to the rubber growers in India.

- **Cardamom Board**

  It was established in 1966 for developing activities to promote extension of cardamom plantation, improving cardamom's quality and for increasing the productivity of cardamom in India.

- **Tobacco Board**

  It was established on January 1, 1976 under the Tobacco Board Act 1975. The main function of the board is to get remunerative prices to the tobacco growers in India.

- **Coconut Board**

  It was established on 12th January 1981 and is headquartered in Kochi, Kerala. Its main function is to contribute to production and marketing of coconut through research and extension services.

- **Coir Board**

  Coir board was established in 1953 under Coir Board Industries Act 1953, at Allepey, Kerala. The Board conducts research on different aspects of coir industry.

Notes

- **Central Silk Board**

  It was set up in 1949 under Central Silk Board Act 1949 in Bangalore. The board is engaged in development of the silk industry, export and import of raw silk.

- **National Horticulture Board (NHB)**

  It was set up in 1984 under Societies Registration Act to promote horticulture crops in the country. The Board also established suitable infrastructure to facilitate production, processing and marketing of horticultural products in India. Credit its support, India's production of horticulture crops is more than the production of food grain crops (cereals, pulses, oilseeds etc.).

- **National Dairy Development Board (NDDB)**

  It was established in 1965 and assigned the job of creating facilities to promote milk production and marketing in the country.

- **Central Warehousing Corporation (CWC)**

  Established in 1962 under Warehousing Corporation Act 1962, it provides logistics support to Indian agriculture sector. It has close to 450 warehouses in India.

- **State Warehousing Corporation (SWC)**

- **Agricultural and Processed Food Products Export Development Authority (APEDA)**

  It was established in 1986 and mandated with development of agricultural exports and maximizes foreign exchange through promotion and facilitation of agri-exports.

- **Marine Products Export Development Authority (MPEDA)**

  It was established in 1972 to undertake promotional work for marine sector, its development and exports from India.

- **Export Inspection Council (EIC)**

  It established to ensure quality of commodities for export from India.

- **Agricultural Produce Market Committee (APMC)**

  APMCs are regulated markets to trade in agricultural and livestock produce.

- **e- National Agriculture Market (e-NAM)**

  This is the unified national electronic market and helps in connecting farmers pan India through expanded market intelligence service.

Cooperative Sector Institutions

- Primary Agricultural Cooperative Marketing Societies
- National Consumers Cooperative Federation
- Farmer Producer Organizations
- National Cooperative Tobacco Growers Federation
- Special Commodity Cooperative Marketing Organizations (Sugarcane, Sugar, Milk)
- National Cooperative Development Corporation (NCDC)
- National Agricultural Cooperative Marketing Federation
- Tribal Cooperative Marketing Federation
- State Cooperative Marketing Federation

INTEXT QUESTIONS 21.5

1. The organization which maintains buffer storage on the behalf of government

   a. National Horticultural Board

   b. APEDA

   c. Food Corporation of India (FCI)

   d. National Dairy Development Board

2. The public sector institution responsible for agricultural export is ....

3. Which organization does declare the MSP (Minimum support price)?

21.7 GOVERNMENT POLICY SUPPORT

21.7.1 Agricultural Price Policy

The agricultural product prices are characterized by

- The supply of agricultural produce does not adjust quickly to changes in demand or price.

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- The cost of production varies across regions.
- The soil characteristics vary from region to region, resulting in application of diverse inputs and adoption of good agricultural practices. As a result, the output quality has large variations.
- Prices decrease during the harvest period and increase during the sowing period. This is due to the simple relationship between supply and prices. As the supply increases during the harvest period, prices fall. When the buyers absorb the supply from the market, prices start to increase. However, at that time, the farmer has nothing to sell.

What comes from this discussion is that the agricultural prices are volatile in nature for various reasons. The Government takes the responsibility of stabilising agricultural prices and takes the responsibility of public distribution through fair price shops or ration shops, and announcing the Minimum Support Prices (MSP) for 24 crops in India. These crops include cereals, pulses, oilseeds, sugarcane, and fibre crops.

History of Agricultural Price Policy:

Commission for Agricultural Costs and Prices (CACP):

CACP was set up in 1965 under the Ministry of Agriculture and Farmers' Welfare upon the recommendations of L.K. Jha Committee. The commission's policy contributions are:

a. **Minimum Support Prices (MSP):** The Cabinet Committee on Economic Affairs reserves the right to recommend the Minimum Support Prices by the CACP. These prices are announced to protect farmers against the steep downward fluctuation in price and act as an assurance against price uncertainty.

b. **Procurement Prices**: These are the price at which the Government procures the food grains for deficit growing states, for serving the poor and below poverty line population and also to the regions that may face drought, floods or other calamities. These are always higher than the MSP.

c. **Issue Prices**: These are below open market prices and always higher than procurement prices. Food grains prices supplied through fair price shops and rationing at subsidized rates are issue prices.

21.7.2 Farmer Producer Organizations (FPO):

It is noted that during the sowing season, farmers, especially marginal and small farmers,

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don't have enough cash in hand to purchase inputs. These farmers are still at the mercy of bigger farmers or traders. Not only this, they face trouble getting their produce to the market on time and fail to negotiate prices with buyers. Over time, it has been observed that due to the challenges that the average farmer faces in India, the next generation does not want to take up farming as a source of living. A big question, therefore, is how to make agriculture a remunerative enterprise and how to retain farmers in it.

The challenge lies in ensuring that small and marginal holdings stay productive and remain the source of livelihoods for millions of people. Cooperatives have been suggested as one way to address problems and issues related to small and marginal farming in India. As a result, a large number of farmer cooperatives were born. However, the success of these cooperatives was limited to a few sectors and unpleasant in others. The cooperatives had to be registered with the Registrar of Cooperatives and focused more on welfare. It should be noted that commercial business was never the aim of cooperatives, so they could never develop themselves along those lines. As the operational area of cooperatives is confined to the boundaries within the state, there was less freedom for them to operate.

In view of the above constraints, the government thought of taking up an initiative and formulating legislation that would enable the incorporation of cooperatives as companies and the conversion of existing cooperatives into companies while ensuring that the main elements of the cooperative business remain intact in the new legislation. Later, on the recommendation of a committee headed by Dr. Y.K. Alagh in 2002, an amendment was made in the Companies Act of 1956. Part IXA was introduced in the Companies Act, named the 'Producer Companies Act.' The producer company has to be registered with the Registrar of Companies.

'Gujarat Cooperative Milk Marketing Federation' marketing dairy products under 'Amul' brand name, IFFCO, and KRIBHCO are among the largest producer cooperatives in the World.

21.7.3 Contract Farming/Marketing:

Contract farming is an agreement between a buyer and a seller where a seller provides the inputs to the farmers and also extension services as well. Quality is monitored to grow a crop as per seller's requirements, and thereby marketing of produce is assured to the farmers. PepsiCo, Kisan, and several other companies are engaged in contract farming in India. The Poultry sector is highly integrated and more than 90 per cent poultry farms run on contract.

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ACTIVITY 2

Visit as many markets as you can. What are the strengths and weaknesses that you noticed? What can be done to improve these markets?

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WHAT YOU HAVE LEARNT

- The term 'Market' is derived from the Latin word 'Marcatus' which means merchandise.
- A market must have defined boundaries. There must be a commodity or good for which the transaction will be carried out.
- As the transaction happens (money for commodity), there must also be buyers and sellers. The buyers and sellers must interact with each other to arrive at equilibrium prices so that the transaction is settled.
- Marketing creates time, place, form, and possession utility via different activities. Storage adds value in terms of time.
- Transportation and logistics are the marketing activities that create place utility for the consumer.
- Processing creates form utility for the customer by adding value to the commodity.
- The goods move from the point of production to the point of consumption through different channels or routes, and in this process, there are stakeholders involved. These routes are known as marketing channels.
- Producers, also known as farmers, are the first functionary in the market.
- Middlemen are essential as they perform different marketing functions, provide services, and add value to the produce.
- Redundant middlemen who do not add any value to the commodity ecosystem are not desirable.

- Middlemen are of four kinds: Merchant Middlemen, Agent Middlemen, Speculative Middlemen, and Facilitative Middlemen.
- In unregulated markets, the commission agent is also known as 'arhatia' and of two types: Kaccha arhatia and Pacca arhatia.
- Brokers are also service providers, but they do not have physical possession of the commodity. A broker brings together the buyers and the sellers so that both parties can negotiate.
- Speculative middlemen have the title to the goods, and they hold this title to make profits.
- Facilitative middlemen facilitate various marketing sub-activities and charge a fee for rendering them.
- The marketing function is defined as any single activity performed in moving a product from the production centre to the consumer.
- Marketing institutions mean all government and private bodies, including farmers and trader bodies, which are involved in marketing functions.
- The Cabinet Committee on Economic Affairs reserves the right to recommend the Minimum Support Prices by the CACP.
- MSP is protection against a steep decline in prices.
- FPOs are farmer collectives engaged in the marketing of inputs and outputs.
- Contract farming is an agreement between a buyer and a seller wherein a seller provides the inputs to the farmers and also extension services and quality monitoring to grow a crop as per his requirements, and thereby assures a market to the farmer.

Notes

TERMINAL QUESTIONS

1. Why do we need more of Farmer Producer Organizations?
2. Discuss marketing functions.
3. What are the different institutions involved in marketing?
4. What is the importance of middlemen in the market?

Notes

5. Describe the agricultural marketing system in India.

6. What do you mean by marketing channels?

7. What is contract farming?

8. What are the benefits of contract farming?

9. What do you understand by Minimum Support Prices?

10. What is procurement price?

ANSWERS TO INTEXT QUESTIONS

21.1

1. Marcatus
2. Demand
3. Seasonal
4. Place utility (option b)
5. Processing

21.2

1. Longer
2. Farmers' market
3. The market channel existing in the agricultural market facilitates the smooth flowing of product to consumers.

21.3

1. Bulk
2. Title
3. Arhatias
4. Facilitative

21.4

1. Tertiary
2. Selling and buying
3. Processing (option b)

Notes

21.5

1. Food Corporation of India (FCI)
2. APEDA (Agricultural and Processed Food Products Export Development Authority)
3. CACP (Commission for Agricultural Costs and Prices)

GLOSSARY

Market: A place where trade or business is conducted.

Marketing function: Any single activity which is performed in moving a product from production centre to the consumers. It includes assembling, processing, distribution, grading, storage risk management, selling etc.

Middlemen: Middlemen are group of persons in distribution chain facilitating flow of products from producer to consumer. They include wholesaler, retailer, village merchants, commission agent or broker.

Title of goods: The speculative middleman has the agreement with the producer to own the product on an agreed price. Further when he sells this product to whole seller or other market actors, he projects as if he is the owner of the product.

Utility: Utility simply means value. Demand is generated when there is utility.

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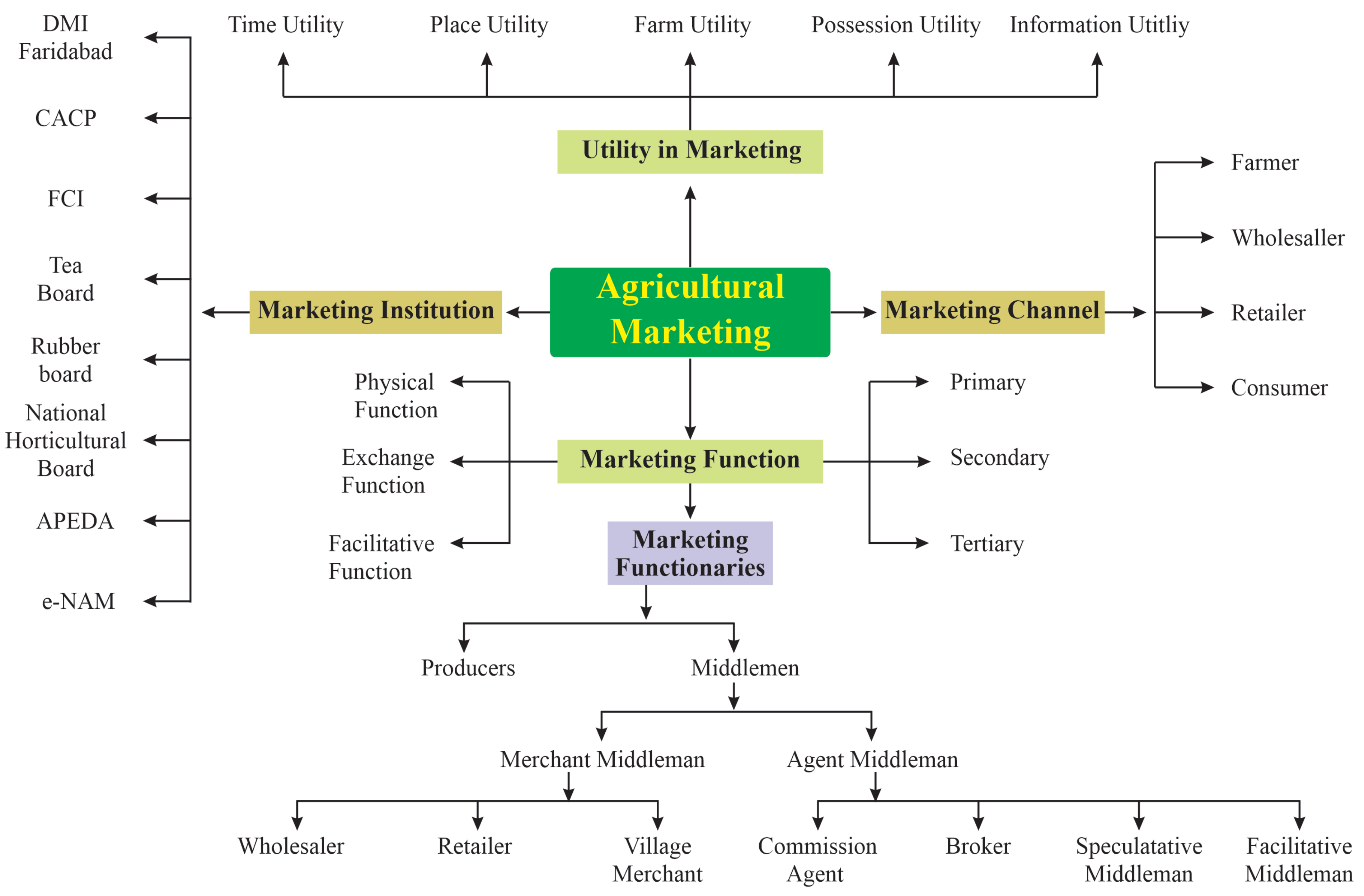
WHAT YOU HAVE LEARNT



22

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AGRICULTURAL FINANCE AND CREDIT IN INDIA

Agricultural credit and finance are the crucial components of the agricultural sector. Agriculture is an unpredictable industry where production relies on various factors, such as, weather, pests, diseases, and market fluctuations, among others. The high cost of inputs, such as, seeds, fertilizers, machinery, and labour require adequate financing. This is where financial institutions play a crucial role by offering a range of financial products and services, including loans, lines of credit, and insurance. Financial institutions help farmers in managing risks and increase productivity by providing the necessary capital to invest on their farms and improve efficiency of operations. Insurance also protects farmers against crop failures, natural disasters, and other unforeseen events. Financial product is the backbone for agricultural growth as it helps in the acquisition of inputs. Purchase of capital assets like, machinery and implements, development of infrastructure for irrigation, etc. depend on the flow of credit in agriculture. These credits are normally financed by financial institutions but in some cases the credit is also financed by non institutional sources, such as, professional money lenders, friends and families etc. Over the year, the share of credit by institutional agencies has been increasing sharply. This may be due to easy accessibility and simple lending process. Therefore, institutional credit system has reduced the burden of high rate of interest which used to be charged by private money lenders.

LEARNING OUTCOMES

After studying this lesson, the learner:

- recalls the necessity of timely availability of credit in agriculture;
- identifies the various public and private agencies working in the field of agriculture finance;

Notes

- differentiates between a cooperative bank and commercial bank and describes their role in agriculture finance;
- explains the concept of microfinance and how the model works in India; and
- assesses the significance of crop insurance and the Kisan Credit Card in supporting the farmers.

22.1 CREDIT AND FINANCE

Finance is an essential element required in any organization or business profession for its efficient operation. The process of financing includes activities, such as, lending, borrowing, and fund management. Agriculture is one of the largest livelihood providers in the country, requiring credit and other financial services. These services boost crop production, crop productivity and help farmers in times of distress, such as, droughts, floods, pests, diseases, and meeting their consumption needs. Credit is a crucial financial product because most farmers in India are small and marginal, with an average landholding less than 1.08 hectares (Agriculture Census 2015-16). These farmers, who hold 86.08% of total landholdings, often have poor or negligible savings and depend on credit to invest in inputs and technology. Additionally, crop insurance is necessary to mitigate the risks associated with agriculture[1].

The agriculture financing system in India consists of institutional sources and non-institutional sources. The institutional sources include commercial banks, credit co-operative banks, regional rural banks, microfinance institutions, and insurance companies working in the field of crop insurance. These institutions are under the purview of regulatory agencies such as Reserve Bank of India (RBI) and National Bank for Agriculture and Rural Development (NABARD). Whereas non-institutional sources of financing include money lenders, traders, friends and family, etc. These non-institutional sources are not regulated by any regulatory agencies.

Before independence, credit to agriculture was financed mainly by non-institutional sources (Central Banking Enquiry Committee Report, 1929 and Report on Agricultural Indebtedness, 1935). According to NSSO 77th round survey on agricultural households, out of total loan outstanding by the agricultural households, 69.6% loans were taken from the institutional sources among which the share of schedule commercial banks stood at 44.5%. The survey showed that loans were also taken from the agricultural and professional money lenders and the share of them in the total loan outstanding was 20.5%. This shows that today also non institutional sources of financing are present in India.

Institutional Credit & Agriculture

In India, the institutional setup for providing credit in agriculture consists of commercial, cooperatives and regional rural banks, which are regulated by the apex bank of our country, i.e., the Reserve Bank of India (RBI), and the National Bank for Agriculture and Rural Development (NABARD). They also refinance the activities of the banks in several areas in the field of agriculture.

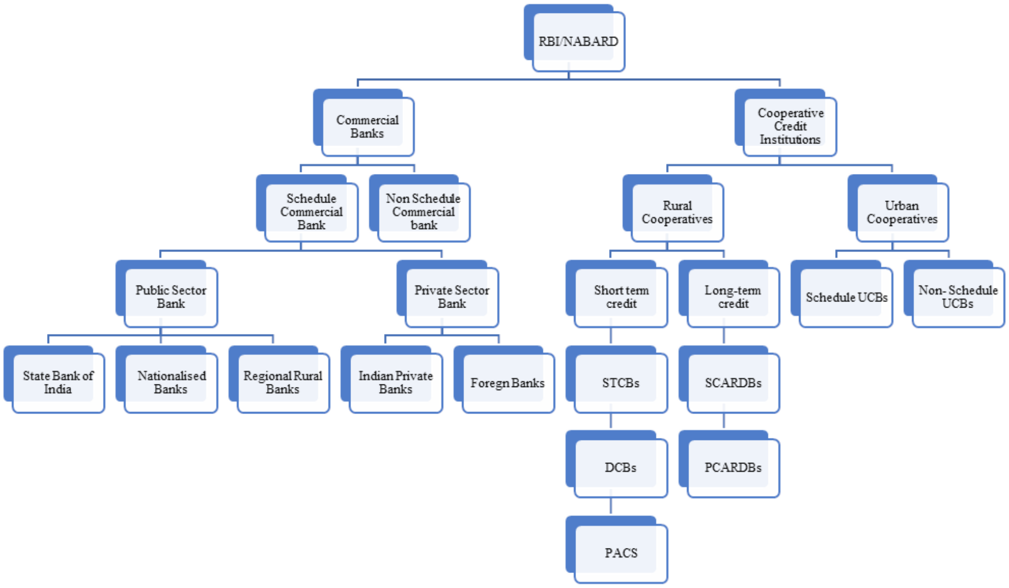

Fig. 22.1: Structure of banking industry in India (Source: RBI, 2007)[2]

22.2 COMMERCIAL BANKS

These are financial institutions that accept deposits from people and provide financial assistance to various individuals and corporations in the form of loans and advances. Besides that, they also perform several agency functions such as collection and payment of dividends, bills of exchange, interest, purchase and sale of securities, etc. These banks generally operate on a profit basis.

Notes

Commercial banks are of two types mainly:

1. Schedule commercial bank
2. Non-schedule commercial bank

Both the above categories of the banks are regulated by Banking Regulation Act 1949. The schedule commercial banks are included in the Second Schedule of RBI. Scheduled bank are those banks which satisfy certain criteria as laid by RBI Act 1934 such as having paid up capital and reserve of not less than Rs. 5 lakhs, their activities should not be detriments of the interest of its depositors and these banks also need to maintain certain average daily balance with RBI.

These banks could further be divided into five groups based on their ownership and operations. These include:

1. State Bank of India
2. Nationalised Public Sector Banks
3. Private Sector Banks
4. Foreign Banks
5. Regional Rural Banks

The structure of Indian banking has evolved regularly since independence. A number of policy initiatives and reforms have been made so that the banking industry could be able to support the development of the economy as a whole. Few major steps post-independence included:

- √ Nationalisation of Reserve Bank of India on 1st January 1949
- √ Enactment of Banking Regulation Act, which empowers the RBI to supervise and regulate the banking industry in India.
- √ In order to increase the flow of rural credit, the committee on All India Credit Survey Report had recommended to form State Bank of India by integrating Imperial Bank of India, 10 major state associated bank and certain small associated bank. Based on this the state bank of India was formulated in the year 1st July 1955.

Most countries in the world have their own central bank to regulate the banking and monetary structure, especially those that issue their own currency. In India, the Reserve Bank of India acts as the country's central bank.

22.2.1 State Bank of India: Structure and functions

It is a multinational public sector bank of India with headquarter in Mumbai, Maharashtra. At present it is largest public sector bank in India. Origin of this bank dates back to pre-independence period in 1921 when Bank of Calcutta, Bank of Bombay and Bank of Madras were merged to form Imperial Bank of India. After independence, this Imperial Bank of India was renamed as State Bank of India in 1955. Before formation of Reserve Bank of India in 1935, it served as central bank of India.

Notes

22.2.2 Nationalised Public Sector Banks

Above initiatives set the ground for the development of banking industry in India, which could be able to support various sectors of the economy and could help the development of the Indian economy. To add to these, 14 largest commercial banks were nationalised during the year 1969 with a deposit of over ₹ 50 crores. These banks were nationalised so that they could give attention to the other priority sectors, such as, agriculture, and small scale industries etc. for the optimum growth of the economy and better utilisation of the resources. These banks include: -

1	Central Bank of India Ltd.	2	Bank of India Ltd.
3	Punjab National Bank Ltd.	4	Bank of Baroda Ltd.
5	United Commercial Bank Ltd.	6	Canara Bank Ltd.
7	United Bank of India Ltd.	8	Dena Bank Ltd.
9	Syndicate Bank Ltd.	10	Union Bank of India Ltd.
11	Allahabad Bank Ltd.	12	India Bank Ltd.
13	Bank of Maharashtra Ltd.	14	Indian Overseas Bank Ltd

Further 6 more banks were nationalised in 1980 with a deposit liability of above or equivalent to ₹ 200 crores. These banks included Andhra Bank Ltd., Punjab and Sind Bank Ltd., New Bank of India Ltd., Vijaya Bank Ltd., Corporation Bank Ltd., and Oriental Bank of Commerce Ltd.

With nationalisation, 85 per cent of banking business comes under public control. The nationalisation of the commercial banks was done to involve them in developing the Indian economy and their resources could be channelized to rapid economic growth with social justice. These nationalised banks are also called public sector banks and

became utmost important player in providing different kind of credit and saving products to farmers. A number of initiatives had been taken to improve the financial health of public sector banks which includes mergers of banks after 1991 as per the recommendation of the Narasimham report. Today at present there are 12 major public sector banks (RBI, 2022).

Table 22.1: Details of Major Public Sector Banks and their merger

Sl. No.	**Name of Public Sector Bank**	**Merged Public Sector Bank**
1.	Bank of Baroda	Dena Bank and Vijaya Bank
2.	Bank of India	-
3.	Bank of Maharashtra	-
4.	Canara Bank of India	Syndicate Bank
5.	Central Bank of India	-
6.	Indian Bank	Allahabad Bank Ltd.
7.	Indian Overseas Bank	
8.	Punjab and Sind Bank	
9.	Punjab National Bank	New Bank of India Ltd., Oriental Bank of Commerce Ltd., and United Bank of India Ltd.
10.	State Bank of India	Merger of SBI with its associated bank
11.	UCO Bank (Formerly United Commercial Bank Ltd.)	-
12.	Union Bank of India	Andhra Bank Ltd., Corporation Bank Ltd.

22.2.3 Private Sector Banks

These are the banks whose major ownership is in the hand of private entities/ corporations. These banks are granted license under banking regulation act to conduct banking operations. The report submitted by the committee on the financial system in 1991 under the chairmanship of Shri M. Narasimham Committee recommended the entry of private sector banks in the banking system of India. The committee proposed that there should be no bar to new banks in the private sector if they conform to the startup capital and other requirements. Based on these recommendations, 10 new banks were licensed by the RBI. Today we have a total of 21 scheduled commercial banks working in the private sector (RBI, 2022).

22.2.4 Foreign Bank

A foreign bank is a financial intermediary which operates outside its home country. These banks are required to comply the norms of both the native country and host country where they operate. Today as per the list of scheduled commercial banks, we have 44 foreign banks operating in the country.

22.2.5 Regional Rural Banks (RRBs)

Regional Rural Banks (RRBs) are also a kind of commercial bank, the banking commission in 1972 identifies that there is a need for a special type of banks to meet the credit need of people living in rural areas; as a result concept of rural bank had been emerged.

A working group was formed under the chairmanship of Shri M. Narasimhan in the year 1975 to provide recommendation on rural banks. The working group recommended the need for setting up a commercial bank which is sponsored by the state and are also regional based as well as rural oriented so that they are aware with the rural problems. These institutions are aimed at mobilising the regional resources available in the area in order to reduce the imbalances in the resources. The primary objective of these institution is to cater the credit need of farmers, labourers, small traders, artisans, and other weaker sections of the society for productive purpose mainly.

As a result, the first five Regional Rural Banks (RRBs) were formed in the year 1975 in Uttar Pradesh, Rajasthan, Haryana and West Bengal. These banks were incorporated under the Regional Rural Bank Act (1976). Their ownership is held by the central government, state government and the sponsor bank in the proportion of 50:15:15,

Notes

respectively. Currently we have 43 RRBs operating in India in different regions as per the list of scheduled Commercial Banks available with RBI.

ACTIVITY 1

Identify the Regional Rural Banks (RRB) present in your area.

....

....

....

22.2.6 Small Finance Bank

On November 27, 2014, RBI issued guidelines for licensing of *small finance banks* in private sector. These banks were registered as a public limited company and granted license under the Banking Regulation Act. These banks were formed with the following objectives:

- √ Provision of saving for unserved and underprivileged sectors of the society
- √ Help in providing credit to small businesses, micro, small and medium enterprises, small and marginal farmers and other unorganised sectors through the utilisation of high technology which could result into low cost of operation.

Hence, the scope of small finance banks is to serve a niche segment of customers as per the above objectives. There are 11small finance banks in India at present.

22.2.7 Payments Banks

Payment banks are also granted license by RBI on the recommendation of the Committee on Comprehensive Financial Services for Small Businesses and Low Income Groups formed under the chairmanship of Dr. Nachiket Mor. Payment banks were formed with the objectives of providing small savings accounts, payment and remittance facilities to migrant labours, low income households, small businesses, and other unorganised entities. These banks provide high volume low value transactions for deposits and remittance purpose. These banks were hence restricted to the acceptance of deposits and remittance services with a low value of transactions. At present there are four schedule payment banks in India. These include India Post Payment Bank

Limited, Fino Payments Bank Limited, Paytm Payments Bank Limited, Airtel Payments Bank Limited.

Note: - list of schedule commercial banks are available at the website of Reserve Bank of India (https://rbi.org.in/scripts/bs_viewcontent.aspx?Id=3657)

INTEXT QUESTIONS 22.1

1. Name the various types of commercial banks exists in India.
2. The bank which acts as central bank of India
   - a. Regional Rural Banks
   - b. State Bank of India
   - c. Reserve Bank of India
   - d. Indian Bank
3. Which bank caters the credit need of people living in rural areas?
4. How many regional rural banks are functioning in India?

ACTIVITY 2

Can you name two foreign banks and private sector banks in India?

....

....

....

22.3 COOPERATIVE CREDIT STRUCTURE

The current cooperative structure of the country can be broadly divided into two parts: rural cooperative credit structure and urban cooperative structure.

A. Rural Cooperative Structure:

The *Rural cooperative structure* consists of the short-term and long-term credit structure.

Notes

The short-term credit structure provides short-term credit requirements of farmers at the grassroot level. It includes

i. **State Central Cooperative Banks (StCBs):** These act as coordinating and regulatory agency between PACS and DCBs, and also act as a link between NABARD, RBI, and the money market. These banks are the custodian of the surplus funds and also receive financial assistance from NABARD and RBI from time to time. They also frame policies related to the organizational matters of PACS and DCBs. They are the apex institutes in this three-tier short-term credit structure.

ii. **District Central Cooperative Banks (DCCBs):** The DCBs are affiliated with the SCBs and act as intermediary agencies. They mobilize funds from SCBs to PACS. It is a federation of all the PACS functioning under one district. They provide assistance to PACS and also help them in smooth functioning. They also conduct general banking business through their branches for members and non-members.

iii. **Primary Agriculture Credit Societies (PACs):** These organizations are organized at the village level to deal directly with individual borrowers. They provide short-, medium-, and long-term loans. Over the years, PACS activities have evolved and now include not only general banking functions but also functions such as input distribution, agro-processing, and storage and warehousing.

The long-term credit structure comprises of a two-tier system

i. The State Cooperative Agricultural and Rural Development Banks (SCARDBs) at the apex level

ii. Primary Cooperative Agricultural and Rural Development Banks (PACARDBs) at the grassroot level.

Different states follow different systems under the long-term credit structure. Some states follow the unitary system, where SCARDBs operate at the state level and have various branches that serve at the grassroots level. On the other hand, some states follow the Federal system, where SCARDBs are at the state level, and at the grassroot level, we have PACARDBs. The SCARDBs provide long-term credit to their members for investment in farm and non-farm activities.

B. Urban Cooperative Structure:

While the urban cooperative structure consists of urban cooperative banks (UCBs), which are primary cooperative banks serving urban and semi-urban areas, providing general banking facilities in those regions. UCBs are registered under the provisions of the State Cooperative Societies Act or the Multi-State Cooperative Societies Act. The banking functions of SCBs, DCBs, and UCBs are regulated by the Reserve Bank of India according to the provisions of the Banking Regulation Act 1949.

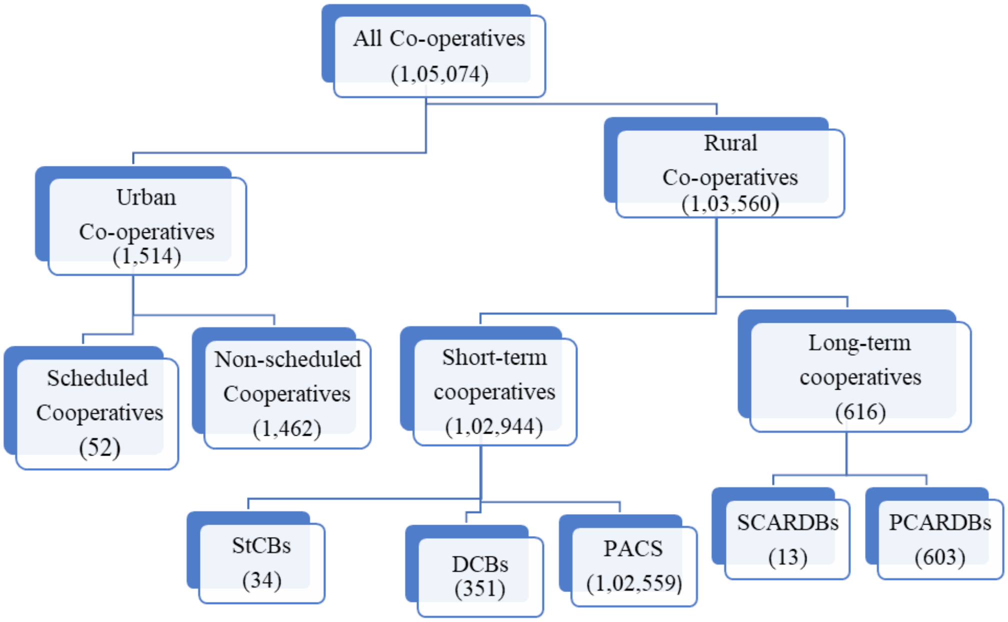

Figure 22.2: Structure of Cooperative in India (Source: RBI, 2022)[3]

INTEXT QUESTIONS 22.2

1. Which of the following cooperative credit structure is found at village level only?

   a. Primary Agriculture Credit Societies

   b. District Central Cooperative Banks

   c. State Central Cooperative Banks

   d. State Bank of India

2. PACARDB provides short term credit in rural areas (True/False).

3. Which cooperative bank does provide banking facilities in urban and semi-urban areas?

22.4 MAJOR TYPES OF INSTITUTIONAL CREDIT

Notes

The total credit requirements of farmers in India could be broadly classified into short-term, medium-term and long-term, based on the purpose and duration of requirements.

A. **Short Term Credit:** It is granted for period of less than 15 months. The short-term credit mainly serves the purpose of farmers such as purchase of seeds, fertilizers, pesticides, and payment of wages to labourers, etc.

B. **Medium Term Credit:** This is required normally for the purchase of implements and machinery, and cattle, etc. The duration of such loans is between a period of 15 months to 5 years.

C. **Long Term Credit:** Long term credit need is required by the farmers for purchase of additional lands, and infrastructure improvements in the farms, etc. The duration of such loans is more than 5 years.

   Before lending the credits to the farmers, banks make the assessment of repaying capacity and accordingly the amount of credit is decided.

The types of credit provided by these financial institutions to the farmers consist namely of followings:

i. **Crop Loans:** It is a short-term loan given to farmers to meet their seasonal agricultural operations. The general duration of crop loans ranges from 6 to 18 months.

ii. **Term Loans:** Loans provided for more than 18 months are called term loans. The main purpose of term loans is to purchase equipment, land, and other investments that support long-term production. Term loans can be categorized into two types:

   - Medium term loans that are repayable within 2-7 years
   - Long term loans that are repayable within 7-15 years

In India these credits are provided mainly through the commercial banks, regional rural banks and cooperatives.

Table 22.2: Percentage share of financial institutions in agriculture credit in India (Source: RBI, 2022)

Year	Cooperatives Banks	Regional Rural Banks	Commercial Banks
2015-16	16.7	13.0	70.2
2016-17	13.4	11.6	75.0
2017-18	12.9	12.1	74.9
2018-19	12.1	11.9	76.0
2019-20	11.3	11.9	76.8
2020-21	12.1	12.1	75.8
2021-22	13.0	11.1	76.0

INTEXT QUESTIONS 22.3

1. The medium term credit is granted for maximum period of
   a. 10 years
   b. 5 years
   c. 15 years
   d. 20 years
2. Which type of credit is required for purchase of seeds, fertilizer or pesticides?
3. Crop loan is a type of long term loan (True/False).
4. Agricultural land or machineries are purchased by the term loans (True/False).

22.5 MICRO FINANCE IN INDIA

Microfinance is the provision of small loans to the poor and vulnerable sections of society. It is a mechanism that ensures that the poor and vulnerable sections receive financial services such as thrift, credit, etc. in small amounts to meet their financial

Notes

product requirements and enable them to increase their income levels and improve their living standards. The concept of modern microfinance was institutionalized by Muhammad Yunus in Bangladesh, who developed a successful model for delivering small loans to rural people through the Grameen Bank.

The emergence of this concept can be traced back to the 16th century when loan funds emerged in Ireland in 1720 to serve the poor. The funds were mainly utilized for lending to traders with poor financial conditions. The loans were interest-free and without collateral. The amount of the loan was small, typically five or ten pounds, and had to be repaid weekly. These funds were seen as an effective tool to alleviate poverty and an excellent example of sustainable microfinance. Several initiatives have been taken by apex authorities to uplift the microfinance movement in India, including the introduction of the self-help group (SHG) bank linkage program and the establishment of microfinance institutions in India.

Generally seven and more people having common interest and goal with mutual understanding can form the self-help group. The members may have equal representation of genders and may involve all communities without any religion bias. The SHG bank linkage approach is based on the savings of group members, usually consisting of 10-20 people from a homogeneous class, who can obtain bank loans. Savings act as partial collateral, and the joint liability characteristic of the group members for the loan ensures timely repayment. The SHG Bank Linkage Programme was introduced in 1992 as a pilot project by NABARD, which aimed to link 500 SHGs to banks. The program was a huge success and emerged as the most popular microfinance model in India. According to NABARD's Annual Report (2022), in 1996, 4,750 SHGs were credit-linked to a bank loan of ₹ 6.06 crore. This number increased to 33.98 lakh SHGs with a credit-linked to ₹ 99729.22 crore and 118.93 lakh SHGs with a deposit of ₹ 47240.48 crore by the year ending March 2022.

The SHG approach helps to build social capital that provides financial services, such as, savings and credit products to the most vulnerable section of society, who were previously not seen as a profitable venture by traditional financial intermediaries due to their income level. The formation of SHGs is based on the concept of "saving first and credit later." This model has led to the building of significant social capital in rural areas and mobilization of savings. It is worth noting that approximately 80% of these groups are exclusively women's groups. The provision of credit enables individuals and businesses to generate livelihood opportunities, thereby increasing income levels and alleviating poverty. Therefore, to reduce poverty and foster overall economic growth, it is necessary to expand and deepen the coverage of this microfinance movement in India.

INTEXT QUESTIONS 22.4

1. Concept of microfinance originated in
   - a. India
   - b. New Zealand
   - c. Netherland
   - d. Ireland
2. Who introduced the concept of modern micro finance?
3. Initiatives to improve microfinance in India are .... and ....

22.6 CROP INSURANCE

Crop insurance is a type of insurance that farmers can purchase to protect themselves from losses that may occur to their crops due to natural disasters, such as, floods, droughts, or other unforeseen perils beyond their control. Therefore crop/livestock insurance acts as protection shield for client (farmers) against adverse situations which may be natural or man-made disasters. The Government of India (GOI) runs four major crop insurance schemes, including:

- **Pradhan Mantri Fasal Bima Yojna (PMFBY):** It provides protection to the farmers against financial losses arising from crop failure due to natural calamities such as drought, flood, natural fire, lightning, pest and diseases, etc. It mainly covers food crops like, cereals, millets and pulses, oilseeds, and annual commercial or horticultural crops as notified by the government.
- **Weather Based Crop Insurance schemes:** It is a kind of insurance which aims to protect the farmers from the losses in the crop production/yield arising because of adverse climatic conditions such as rainfall, temperature, and humidity etc. It covers food crops, oilseeds and horticultural or commercial crops as notified by the government.
- **Coconut Palm Insurance Scheme:** This scheme was launched to provide protection to palm growers against the risks arising due to the failure of palms due to pest diseases, climatic changes, and natural disasters.
- **Unified Package Insurance Scheme:** It is a comprehensive scheme that includes not just one insurance policy, but a bouquet of several insurances that

Notes

may be needed by farmers to safeguard them from financial losses. It covers a total of seven sections. The sections covered under the scheme include:

- Crop insurance
- Personal accident insurance
- Life insurance
- Building and contents insurance (Fire and allied hazards)
- Agriculture pump set insurance
- Student safety insurance and
- Agriculture tractor insurance

Among these, crop insurance is a mandatory section that farmers must choose. However, farmers need to select at least two other sections from the remaining six in order to qualify for the applicable subsidy under the crop insurance section. Further animal insurance schemes are also being implemented in India wherein cows, buffalos and other small animals are insured. There are government guidelines for smooth implementation of livestock insurance schemes in the country.

22.7 KISAN CREDIT CARD

The introduction of Kisan Credit Card (KCC) scheme was done in the year 1998. The main aim to issue KCC is to provide credit to the farmers timely and hassle free under a single window system. KCC is short-term credit along with a component of long-term credit which aims to meet the following requirements of the farmers:

- Short-term credit requirement to meet the cultivation cost and maintenance cost
- Post-harvest expense
- Marketing loan for the produce
- To meet the consumption requirement
- Long-term investment need for agriculture and allied activities

The repayment period is generally fixed by banks based on the anticipated harvesting and marketing periods required for the crops for which the loan has been granted. The term loans are typically repayable within a period of 5 years. The financial institutions that introduce KCCs include public and private sector banks, RRBs, and cooperative banks.

INTEXT QUESTIONS 22.5

1. A farmer can reduce his loss due to natural disaster by purchasing ....

2. Give two examples of crop insurance scheme run by Government of India. ....

3. Kisan Credit Card was introduced in

   a. 1994

   b. 1998

   c. 2000

   d. 2004

4. What was the main purpose behind the introduction of Kisan Credit Card (KCC)?

WHAT YOU HAVE LEARNT

- The term finance means activities, such as, lending, borrowing and management of funds.
- The agriculture financing system in India consists of financial institution namely commercial banks, credit co-operatives banks, regional rural banks, microfinance institutions, insurance companies working in the field of crop insurance.
- Commercial banks are the financial institutions that accept the deposits from the people and provide financial assistance to various individuals and corporations in the form of loans and advances.
- The current cooperative credit structure of the country can be broadly divided into two parts: rural cooperative credit structure and urban cooperative structure.
- Micro finance is the provision of small loan to vulnerable and poor section of the society.
- The main aim to issue KCC is to provide timely and hassle free credit to the farmers under a single window system.

TERMINAL QUESTIONS

1. Define the structure of Indian baking system.
2. What is the reason behind nationalization of banks in India?
3. Differentiate between crop loan and term loan.
4. Why Crop insurance is important for farmers?
5. Explain the concept of
   a. Micro Finance
   b. Crop Insurance
   c. Regional Rural Banks
   d. Small finance and payment banks

ANSWERS TO INTEXT QUESTIONS

22.1

1. State Bank of India, Nationalized Public Sector Banks, Private Sector Banks, Foreign Banks, Regional Rural Banks
2. Reserve Bank of India (option c)
3. Regional Rural Bank
4. 43

22.2

1. Primary Agriculture Credit Societies (Option a)
2. False
3. Urban cooperative banks (UCBs)

22.3

1. 5 years (option b)
2. Short term credit
3. False
4. True

22.4

1. Ireland (option d)
2. Mohammad Younus
3. The self-help group-bank linkage program and the establishment of microfinance institutions

22.5

1. Crop insurance
2. Pradhan Mantri Fasal Bima Yojna (PMFBY) and • Weather Based Crop Insurance schemes
3. 1998 (option b)
4. To provide timely and hassle-free credit to the farmers through a single window system

GLOSSARY

Agricultural Cooperative: An agricultural cooperative in India is a voluntary association of individuals who work together in farming to achieve their common goals (e.g., agricultural production, marketing of agri-products etc).

Agricultural Credit: The quantity of investment money made available for agricultural output is known as agricultural credit.

Commercial Bank: Financial institutions that accept deposits from people and provide loans to various individuals and corporations in the form of loans and advances.

Finance: It is an essential element required in any organization or business profession for its efficient operation. The process of financing includes activities, such as, lending, borrowing, and fund management.

Microfinance: It is the provision of supplying small loans to the poor and vulnerable sections of society.

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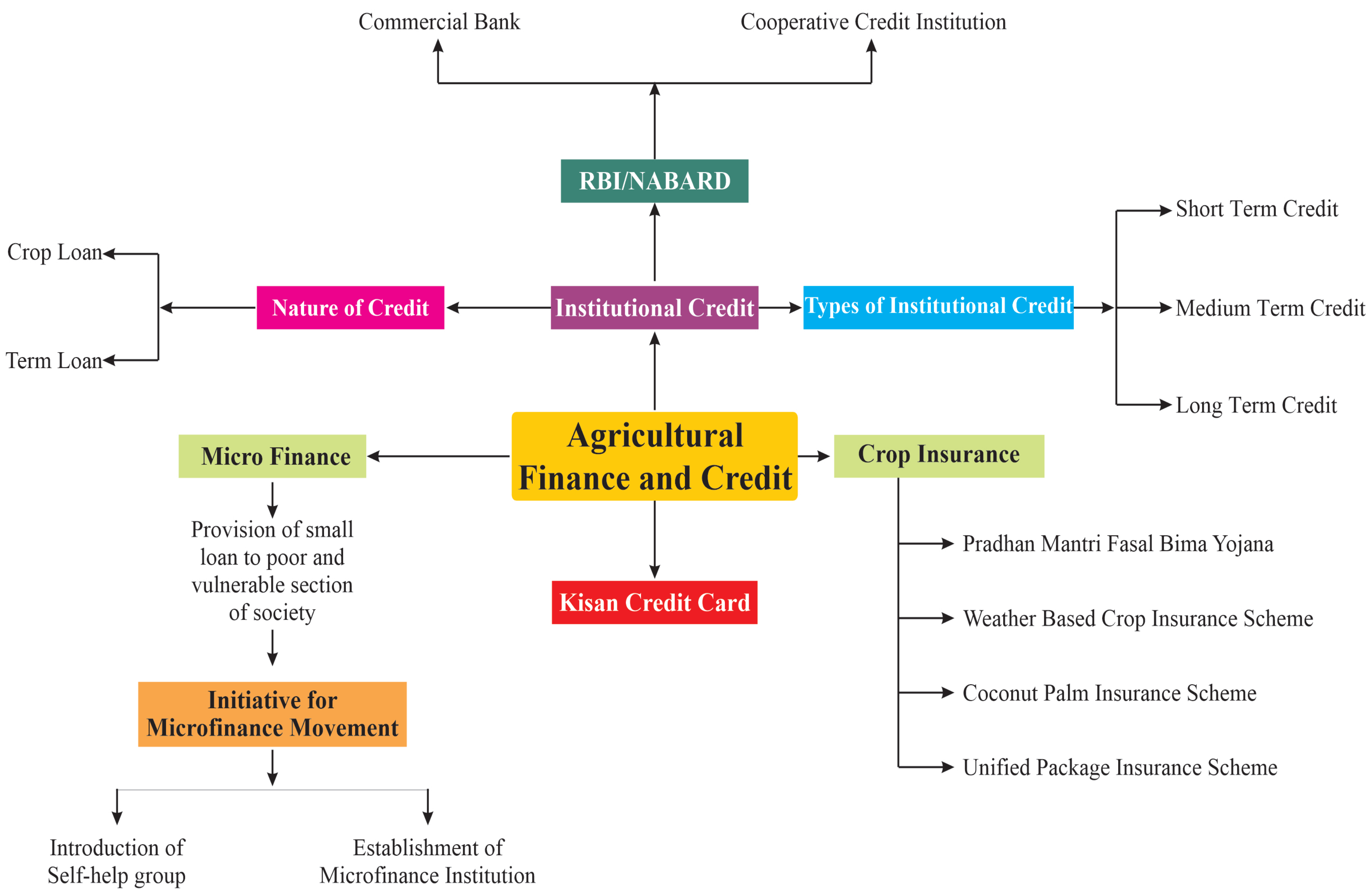
Notes

WHAT YOU HAVE LEARNT



MODULE - 6

Enterprises in Agriculture

23. Entrepreneurship: Nature, Types and Levels

24. Importance of Self-help Groups in Agriculture and Village Economy

25. Career Opportunities in Agriculture Sector

23

383KRISHICH23

ENTREPRENEURSHIP: NATURE, TYPES AND LEVELS

India's economy is growing rapidly despite the unfavorable geopolitical conditions. Recently, India witnessed corona pandemic, but it took this challenging situation as an opportunity to demonstrate its capability and strength to the world by swiftly manufacturing vaccines and other healthcare services on a large scale. Agriculture has contributed significantly during this period and it has been crucial to India's growth story. Sustainable agricultural growth can be achieved by intensifying, diversifying, and commercializing the agricultural and allied activities.

With changing food habits and increased demand for ready-to-eat foods, a strong and effective food processing sector will play a significant role in diversifying agricultural activities, enhancing value addition, generating employment, creating new job opportunities and generating surplus for the export of agri-food products. This will require policies and plans for improvement of agriculture and allied sectors, including the adoption of advanced technology, enforcement of quality standards, and strengthening the domestic market with a focus on international markets. This would also require promotion of entrepreneurship in the society, particularly in the agriculture sector.

LEARNING OUTCOMES

After studying this lesson, the learner:

- defines the concept of entrepreneur, entrepreneurship and enterprise;
- appraises entrepreneurship as a career option;
- plans to inculcate the skills of a successful entrepreneur;
- identifies the stages of enterprise development;

- differentiates between MSMEs and large enterprises; and
- cites examples of successful entrepreneurial models in agriculture.

Notes

23.1 WHAT DO WE MEAN BY ENTREPRENEURSHIP?

The word 'entrepreneur' is derived from French verb 'entreprendre' which means ‘to undertake.’ This refers to those who undertake the risk of setting up of new enterprise(s). Entrepreneurship is not merely a technique of conducting a business; it is a mindset originating from the basic human needs or crisis, the desire to create wealth for oneself and add value to the society. It fosters the formation of wealth and adding value to the society through innovation and creativity.

Entrepreneurism is not just about making money, setting up of startup, or owing a business, but a way of life. It reflects a need driven desire to innovate and generate new ideas, keeping businesses contemporary. It embodies the spirit of every individual, in essence, as a knowledge driver’s discipline.

Entrepreneurship is the process of identifying, creating, and working on the opportunities to start or manage an enterprise. An entrepreneur is thus someone who organizes, manages and assumes risks of a business or enterprise. This process involves taking calculated risks, innovating, and mobilising resources to establish and grow a business with the goal of generating profits and creating value for the society.

Let us start with definition of Entrepreneurship.

Entrepreneurship is a human activity being instrumental in economic development. Anyone who runs a small, medium or large business is considered an entrepreneur. Entrepreneurs can operate independently or work as part of a team or partnership. An entrepreneur is thus someone who organizes, manages and assumes risks of a business or enterprise. Some important definitions of the entrepreneurship are as follows:

- Entrepreneurship is the process of bearing the risk of buying at certain prices and selling at uncertain prices (Paul Di-Masi).
- An entrepreneur is an individual who bears the risk of opening a business in the expression of uncertainty about the future conditions (Encyclopedia Britannica).
- An entrepreneur is a person, who is capable to look at the environment, recognize opportunities, get enhanced the environment and implement action to maximize these opportunities (Robert E. Nelson).

- Entrepreneur is the one who innovates and introduces something new in the economy (Joseph A. Schumpeter).
- Innovation is a specific tool of our entrepreneurs (Peter F. Drucker).
- Entrepreneurship is defined as self-employment of any sort (Richard Cantillon).
- Entrepreneurs attempt to predict and act upon changes within markets (Frank Knight).

Notes

Entrepreneurship is the ability to identify promising opportunities for business development with the appropriate set of resourcefulness, managerial skills, knowledge, risk-taking ability, creativity, persistence and economic motivation to exploit these opportunities in the best possible ways. The practice of starting new enterprises, particularly businesses, generally in response to identified opportunities is all about taking the risks. It has been observed that a large number of new ventures fail. Hence, it is tough and risky to be an entrepreneur but at the same time the ones who are successful create immense wealth not only for themselves but also for the society.

23.2 NEED TO BECOME AN ENTREPRENEUR

There are several reasons why individuals choose to become entrepreneurs. Two important aspects include **the joy of being self-employed** and **the benefits to society.**

A. The joy of being an Entrepreneur (self-employed)

a. ***Autonomy and Independence:*** As an entrepreneur, you will have the freedom to make your own decisions, set your own goals, and determine your own path. You are not bound by the constraints of traditional employment, allowing you to explore your passions and interests freely.

b. ***Personal Fulfillment:*** Building and growing your own business can be incredibly rewarding. It provides a sense of accomplishment and personal fulfillment that comes from seeing your ideas come to life, overcoming challenges, and achieving success on your own terms.

c. ***Financial Potential:*** Entrepreneurship offers the potential for financial independence and prosperity. By building a successful business, you can create wealth and financial security for yourself and your family.

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B. Benefits to the society

a. ***Job Creation:*** Entrepreneurs are often at the forefront of job creation. They establish new businesses and expand existing ones, leading to increased employment opportunities for others. This helps reduce unemployment rates and stimulates economic growth.

b. ***Innovation and Progress:*** Entrepreneurs are driven by a desire to solve problems and create value. They develop new products, services, and technologies that address societal needs and improve people's lives. Entrepreneurial ventures often drive innovation and push the boundaries of what is possible.

c. ***Economic Development:*** A thriving entrepreneurial ecosystem contributes to overall economic development. It attracts investment, fosters competition, and drives productivity. Successful entrepreneurs pay taxes, contribute to the local economy, and can even inspire others to start their own businesses.

It's important to note that entrepreneurship also involves challenges and risks, such as financial uncertainty, need for consistent efforts in the face of adversity, and the necessity to adapt to changing market demands, and a high level of responsibility. However, for those who are motivated, passionate, and willing to embrace these challenges, the joy of being self-employed and the potential benefits to society can make entrepreneurship an attractive and fulfilling choice.

INTEXT QUESTIONS 23.1

1. What is one aspect of being self-employed that brings joy to entrepreneurs?

   a. Financial stability

   b. Autonomy and independence

   c. Fixed work hours

   d. Limited responsibility

2. How can being self-employed as an entrepreneur lead to personal fulfillment?

   a. By having limited challenges and obstacles

   b. By aligning personal passions and interests with business pursuits

c. By avoiding risks and uncertainties

d. By relying on others to make important decisions

3. What is one benefit to society that arises from entrepreneurial activities?

a. Decreased job opportunities

b. Reduced economic growth

c. Increased unemployment rates

d. Job creation

4. How do entrepreneurs contribute to innovation and progress in society?

a. By following traditional approaches and methods

b. By avoiding risks and sticking to existing ideas

c. By addressing societal needs and developing new solutions

d. By discouraging creativity and experimentation

5. How does entrepreneurship contribute to economic development?

a. By discouraging investment and competition

b. By limiting productivity and growth

c. By attracting investment and fostering competition

d. By increasing unemployment rates

ACTIVITY 1

1. Below is an activity to explore the reasons for choosing to be an entrepreneur.
2. Divide the participants into small groups or pairs.
3. Provide each group with a large sheet of paper and markers.
4. Instruct the groups to create a mind map or a visual representation of the joy of being self-employed and the benefits to society.
5. Ask the groups to brainstorm and list as many points as possible related to each aspect.

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6. Encourage them to think creatively and consider personal experiences, real-life examples, and societal impact.

7. After a set time, ask each group to present their mind map to the rest of the participants.

8. Facilitate a discussion by asking the following questions:

   - What are some common themes or ideas that emerged from the different groups?
   - Did any unique perspectives or examples come up that were not considered before?
   - How do the joy of being self-employed and the benefits to society intertwine or complement each other?
   - Can you think of any real-life entrepreneurs or businesses that exemplify these aspects?
   - How do these reasons for choosing entrepreneurship align with your personal values and goals?

9. Encourage participants to reflect on their own aspirations and motivations for entrepreneurship based on the insights gained from the activity.

10. Conclude the activity by highlighting the diverse ways in which entrepreneurship can bring personal fulfillment and positively impact society.

This activity aims to stimulate discussion, promote critical thinking, and encourage participants to explore the multifaceted aspects of being an entrepreneur. It allows them to delve into the joys of self-employment and understand the broader implications of entrepreneurship on society.

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22.3 TRAITS OF A GOOD ENTREPRENEUR

Entrepreneurial traits contribute significantly to the entrepreneurial mindset and success. While individuals may naturally possess varying degrees of these traits, they can also

be developed and nurtured through experience, learning, and personal growth. Following are some key traits of a successful entrepreneur:

1. ***Creative and Innovative:*** Entrepreneurs are creative thinkers who generate novel ideas and solutions. They are not limited by conventional thinking and are open to exploring new approaches and perspectives. This enables them to develop unique products, services, and business models that differentiate them apart from others in the market.

2. ***Risk-Taking:*** Entrepreneurs are comfortable with taking risks and embracing uncertainty. They understand that entrepreneurship inherently involves risk and they are willing to take calculated risks to pursue opportunities. Successful entrepreneurs assess risks, make informed decisions, and manage uncertainties effectively.

3. ***Initiative and Drive:*** Entrepreneurs possess a strong sense of initiative and are self-starters. They take the lead in starting new ventures and are proactive in pursuing their goals. Their high level of motivation and drive fuels their ambition and determination to succeed.

4. ***Persistence:*** Persistence is a crucial trait for entrepreneurs, as they often face obstacles, failures, and setbacks along their entrepreneurial journey. Successful entrepreneurs exhibit perseverance and resilience, bouncing back from challenges, learning from failures, and staying committed to their vision even in the face of adversity.

5. ***Opportunity Seeking:*** Entrepreneurs have a keen eye for identifying opportunities. Their entrepreneurial mindset enables them to spot gaps, unmet needs, or untapped markets. By identifying and capitalizing on opportunities, they create value and differentiate themselves from competitors.

6. ***Information Seeking:*** Entrepreneurs are proactive in seeking and acquiring new knowledge. They stay informed about industry trends, market conditions, customer preferences, and technological advancements. This knowledge enables them to make well-informed decisions and stay ahead in their fields.

7. ***Seeking and Using Feedback:*** Entrepreneurs actively seek feedback from various sources, such as mentors, advisors, customers, and employees. They value constructive criticism and use it as an opportunity for improvement. By incorporating feedback, entrepreneurs can refine their products, services, and business strategies, ultimately increasing their chances of success.

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8. ***Concern for Standard/Quality of Work:*** Entrepreneurs are dedicated to maintaining high standards and delivering quality work. They prioritize customer satisfaction and take pride in their offerings. By ensuring quality, they build a positive reputation, foster customer loyalty, and establish a competitive edge.

9. ***Self-Confidence:*** Self-confidence allows entrepreneurs to believe in their abilities and ideas. It enables them to take bold actions, overcome self-doubt, and navigate challenges with resilience. Self-confidence is also crucial for building their credibility and influencing others.

10. ***Problem-Solving Orientation:*** Entrepreneurs have a natural inclination towards problem-solving. They view problems as opportunities and are adept at identifying, analyzing, and finding effective solutions. This trait helps them to address challenges creatively, adapt to changing circumstances, and continuously improve their businesses.

11. ***Goal Setting:*** Entrepreneurs set clear and specific goals for themselves and their ventures. They define milestones, targets, and objectives that align with their vision. By setting goals, entrepreneurs provide direction, focus their efforts, and measure progress while also motivating themselves and their team members.

12. ***Faith in Planning:*** Entrepreneurs understand the importance of strategic planning. They develop comprehensive business plans that outline their vision, mission, target market, competitive analysis, and growth strategies. Confidence in planning allows them to make informed decisions, allocate resources effectively, and navigate their entrepreneurial journey with clarity.

13. ***Persuasive and Influencing Quality:*** Entrepreneurs possess strong communication and interpersonal skills. They can persuasively articulate their ideas, vision, and value proposition to various stakeholders, such as investors, partners, employees, and customers. Effective persuasion and influence help them build partnerships, secure funding, attract customers, and foster collaborations.

14. ***Long-Term Commitment:*** Entrepreneurship requires long-term commitment and dedication. Successful entrepreneurs are willing to invest the time, effort, and sacrifices necessary to build and grow their ventures. They understand that entrepreneurial success often takes time and patience, and they remain committed to their vision even during challenging periods.

Notes

INTEXT QUESTIONS 23.2

1. Which trait of an entrepreneur involves being proactive and self-motivated?

   a. Initiative and drive

   b. Information seeking

   c. Self-confidence

   d. Long-term commitment

2. Which trait of an entrepreneur involves the ability to bounce back from challenges and setbacks?

   a. Persistence

   b. Opportunity seeking

   c. Faith in planning

   d. Problem-solving orientation

23.4 DIFFERENT STAGES OF ENTREPRENEURSHIP

The entrepreneurial journey is not always linear, and entrepreneurs may experience challenges, pivots, and adjustments at each stage. The duration and specific activities within each stage can vary depending on the nature of the business, industry, and individual circumstances. Typically, the entrepreneurial journey consists of several stages that entrepreneurs go through as they start, develop, and grow their ventures. Here are the key stages of entrepreneurship:

1. ***Idea Generation and Opportunity Recognition:*** This is the initial stage where entrepreneurs generate ideas and identify opportunities in the market. They explore various industries, trends, and customer needs to develop innovative business ideas.

2. ***Feasibility Analysis and Market Research:*** Once an idea is generated, entrepreneurs conduct feasibility analysis and market research to assess the viability and potential of their business concept. They analyze the target market, competitors, and customer preferences to determine if their idea is feasible and viable.

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3. ***Business Planning and Development:*** At this stage, entrepreneurs create a comprehensive business plan that outlines their vision, mission, goals, strategies, and financial projections. They refine their business concept, define their value proposition, and establish a roadmap for their venture.

4. ***Startup and Launch:*** Entrepreneurs begin executing their business plan and officially launch their venture. They set up the necessary infrastructure, acquire resources, and begin operations. This stage involves securing funding, establishing legal structures, and building initial customer relationships.

5. ***Growth and Scaling:*** In the growth stage, entrepreneurs focus on expanding their customer base, increasing sales, and achieving sustainable profitability. They refine their products or services, optimize operations, and explore opportunities for scalability. This stage may involve hiring additional employees, entering new markets, or introducing new product lines.

6. ***Adaptation and Innovation:*** As the business grows, entrepreneurs must continuously adapt to changes in the market and industry shifts. They embrace innovation and explore new technologies, in order to stay ahead of their competitors. This stage involves ongoing monitoring of customer feedback, market trends, and industry developments.

7. ***Consolidation and Expansion:*** At this stage, successful entrepreneurs consolidate their position in the market and explore opportunities for further expansion. They may consider diversification, partnerships, mergers, acquisitions, or international expansion to reach new markets and achieve sustained growth.

8. ***Exit or Succession:*** Entrepreneurs may choose to exit their ventures by selling the business or transferring ownership. This stage involves careful planning and execution to ensure a smooth transition. Alternatively, they may plan for succession to pass the business on to the next generation or a chosen successor.

INTEXT QUESTIONS 23.3

1. During which stage of entrepreneurship do entrepreneurs conduct the market research and assess the viability of their business idea?

   a. Growth and scaling

   b. Adaptation and innovation

c. Business planning and development

d. Feasibility analysis and market research

2. What is the main focus of the startup and launch stage of entrepreneurship?

a. Consolidation and expansion

b. Growth and scaling

c. Feasibility analysis and market research

d. Setting up operations and officially launching the venture

3. In which stage of entrepreneurship do entrepreneurs refine their products or services and optimize their operations?

a. Startup and launch

b. Growth and scaling

c. Adaptation and innovation

d. Exit or succession

23.5 TYPES OF ENTERPRISES

When categorizing entrepreneurs based on the size of their enterprises, we typically refer to micro, small, medium (MSMEs), and large enterprises. These classifications are generally based on factors such as the number of employees, annual turnover, or assets.

The different types of enterprises are outlined below:

23.5.1 Micro Enterprises:

Micro enterprises are the smallest in size and typically have fewer than 10 employees. They are often started by individual entrepreneurs or self-employed individuals and usually operate on a small scale, serving local or niche markets. Examples include individual retail shops, small-scale artisans, freelancers, or home-based businesses.

23.5.2 Small Enterprises:

Small enterprises have slightly larger operations compared to micro enterprises. The specific criteria for defining small enterprises may vary by country or industry, but they

generally include 10 to 50 employees. Small enterprises typically have a higher level of organization and may require additional resources and infrastructure. Examples include small restaurants, boutique stores, local manufacturing units, or specialized service providers.

Notes

23.5.3 Medium Enterprises:

Medium enterprises are larger than small enterprises and have a more significant scale of operations. Generally, medium enterprises employ 50 to 250 people. Medium enterprises often have well-established processes, systems, and structures in place. They often serve regional or national markets and have higher annual turnover and assets. Examples include regional distributors, medium-sized manufacturing firms, or professional service firms.

The Ministry of Micro, Small and Medium Enterprises (MSME), Government of India, has proposed classifying micro, small and medium enterprises based on composite criteria: investment in plant & machinery/equipment and annual turnover (https://msme.gov.in/know-about-msme).

	Micro Enterprises	Small Enterprises	Medium Enterprises
Investment in plant and machinery or equipment	Not more than Rs.1 crore	Not more than Rs.10 crores	Not more than Rs.50 crores
Annual turnover	Not more than Rs. 5 crores	Not more than Rs. 50 crores	Not more than Rs. 250 crores

23.5.4 Large Enterprises

Large enterprises are the largest in terms of size and often have a substantial market presence. They employ more than 250 employees and typically possess significant assets and annual turnover. Large enterprises have well-developed organizational structures, extensive resources, and often operate across multiple regions or internationally. Examples include multinational corporations, conglomerates, or industry leaders across various sectors.

It's important to note that specific criteria and definitions for micro, small, medium, and large enterprises can vary between countries and industries. Governments and organizations frequently establish guidelines and classifications to provide support, incentives, and regulatory frameworks tailored to the needs of different-sized enterprises. These classifications help policymakers, researchers, and entrepreneurs better understand and address the specific challenges and opportunities faced by businesses of different scales.

INTEXT QUESTIONS 23.4

1. What is the defining characteristic of a large enterprise?

   a. Small scale of operations

   b. Less than 10 employees

   c. 50 to 250 employees

   d. More than 250 employees

2. Which type of enterprise is typically started by individual entrepreneurs or self-employed individuals?

   a. Micro enterprise

   b. Small enterprise

   c. Medium enterprise

   d. Large enterprise

23.6 ENTREPRENEURSHIP AS A CAREER

Entrepreneurship as a career offers unique opportunities and challenges for individuals who are passionate about creating their own path and making a meaningful impact. Entrepreneurship comes with risks and uncertainties and therefore requires resilience, adaptability, and a willingness to embrace failure as a learning opportunity. However, for those who are driven, passionate, and determined, entrepreneurship can be an incredibly fulfilling and rewarding career choice. Here are some key aspects of pursuing entrepreneurship as a career:

Notes

1. ***Independence and autonomy:*** As an entrepreneur, you have the freedom to shape your own destiny. You have the autonomy to make decisions, set your own goals, and determine the direction of your business. This level of independence allows you to pursue your passions and build a career around what truly matters to you.

2. ***Innovation and creativity:*** Entrepreneurship provides a platform for you to unleash your creativity and innovation. It allows you to identify problems, develop unique solutions, and create products or services that have the potential to improve the industrial productivity and meet market demands in new ways. As an entrepreneur, you have the freedom to experiment, iterate, and bring your ideas to life.

3. ***Impact and fulfillment:*** Building a business and seeing it grow can be immensely rewarding. As an entrepreneur, you have the opportunity to make a positive impact on society by solving problems, creating jobs, driving economic growth, or contributing to social causes. The sense of fulfillment that comes from building something meaningful and leaving a lasting legacy can be deeply satisfying.

4. ***Financial potential:*** While entrepreneurship involves risks, it also offers the potential for financial rewards. As a successful entrepreneur, you have the opportunity to create wealth and achieve financial independence. By building a scalable and profitable business, you can generate income and create value for yourself and your stakeholders.

5. ***Continuous learning and personal growth:*** Entrepreneurship is a journey of constant learning and personal growth. You'll face various challenges and obstacles along the way, which will push you to acquire new skills, develop resilience, and adapt to changing circumstances. The entrepreneurial journey offers opportunities for self-improvement and acquiring a diverse set of skills that can benefit you in all aspects of life.

6. ***Flexibility and work-life balance:*** As an entrepreneur, you have the flexibility to design your work-life balance according to your preferences. While starting a business requires hard work and dedication, it also provides the flexibility to set your own schedule, prioritize family or personal commitments, and create a lifestyle that aligns with your values.

7. *Networking and collaboration:* Entrepreneurship allows you to connect with like-minded individuals, mentors, investors, and industry experts. Building a network of supportive contacts can provide valuable guidance, open doors to

opportunities, and help you overcome challenges. Collaboration and partnerships with other entrepreneurs can lead to synergistic growth and shared success.

Case Studies:

1. Rikin Gandhi - Digital Green

Rikin Gandhi is the co-founder of Digital Green, a nonprofit organization that leverages technology to empower smallholder farmers in India. Digital Green uses videos and community-based interventions to disseminate agricultural information and best practices. The organization trains local farmers to create and share videos showcasing their successful farming techniques. These videos are shared within communities, allowing farmers to learn from their peers and adopt improved agricultural practices. Digital Green has reached thousands of farmers across India, improving their agricultural productivity and livelihoods.

You can access Digital Green by following this link: https://www.digitalgreen.org/

2. Naveen Jain - FarmersFZ

Naveen Jain is the founder of Farmers Fresh Zone (FarmersFZ), an agritech startup that connects farmers directly with consumers in urban areas. FarmersFZ operates an online platform where farmers can sell their produce directly to consumers, eliminating intermediaries and ensuring fair prices for both farmers and consumers. The platform also provides logistics and delivery support, enabling farmers to reach a wider market. FarmersFZ has successfully bridged the gap between farmers and consumers, promoting transparency in the supply chain and providing a sustainable market for farmers' produce.

You can explore various services offered by FarmersFZ to the crop producers through their website (https://farmersfz.com/).

3. Kiran Patil - Organic Mandya

Kiran Patil is the founder of Organic Mandya, an organization promoting organic farming practices in the Mandya district of Karnataka, India. Organic Mandya works closely with farmers and provides them with training, organic inputs, and market linkages for their produce. The organization also helps farmers obtain organic certifications, enabling them to access premium markets. Through these efforts, Organic Mandya has transformed numerous conventional farmers into successful organic farmers, promoting sustainable agriculture and improving farmers' incomes.

Notes

These case studies demonstrate the diverse entrepreneurial endeavors in the agricultural sector of India. These entrepreneurs have leveraged technology, created innovative business models, and established platforms to address the challenges faced by farmers and promote sustainable agriculture. Their efforts have not only created successful ventures but also positively impacted farmers' lives, agricultural practices, and the overall agricultural ecosystem.

INTEXT QUESTIONS 23.5

1. Entrepreneurship encourages:
   a. Following conventional paths
   b. Minimal innovation and creativity
   c. Risk-taking and problem-solving
   d. Reliance on others for direction
2. The entrepreneurial journey involves:
   a. No learning or personal growth
   b. Fixed work schedules and limited networking
   c. Financial instability and no potential for wealth creation
   d. Constant learning and adaptation
3. Networking and collaboration are important for entrepreneurs because they:
   a. Limit exposure to diverse perspectives and ideas
   b. Stifle innovation and creativity
   c. Provide guidance and open doors to opportunities
   d. Impede personal growth and development

ACTIVITY 2

Visit the websites of Digital Green (https://www.digitalgreen.org/) and FarmersFZ (https://farmersfz.com/). Explore the services available for farmers in these websites.

Make a list of these services. Do you think these are sufficient for good crop production? If not, mention your suggestions.

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WHAT YOU HAVE LEARNT

- Entrepreneurship involves the process of identifying, creating, and pursuing opportunities to develop and manage a business venture. Entrepreneurs are individuals who take risks and organize resources to transform innovative ideas into viable businesses. The lesson discusses the motivations behind choosing entrepreneurship as a career, such as the joy of being self-employed, the desire for independence and autonomy, the opportunity for financial success, and the ability to make a positive impact on society.
- Successful entrepreneurs typically possess certain traits that contribute to their effectiveness. These include creativity and innovativeness, risk-taking ability, initiative , initiative persistence, opportunity-seeking, information-seeking, the ability to seek and use feedback, a concern for standards/quality of work, self-confidence, problem-solving orientation, goal-setting, faith in planning, persuasive and influencing qualities, and long-term commitment.
- The entrepreneurial journey consists of distinct stages, including opportunity identification and evaluation, business planning and launch, growth and expansion, and maturity or exit. Each stage presents unique challenges and opportunities. Enterprises can be categorized based on their size, such as micro, small, medium, and large enterprises. Each category has specific characteristics, including employee count, annual turnover, and investment criteria. Entrepreneurship as a career offers individuals opportunities for independence, autonomy, creativity, and a profound impact on society. Although it involves risks and uncertainties, it also provides financial potential, personal growth, flexibility, networking, and collaboration.

TERMINAL QUESTIONS

1. Entrepreneurship is the process of starting and managing one's own business. Comment.

2. How does the joy of being self-employed and catering to the societal benefits intersect to create a mutually beneficial relationship in sustaining entrepreneurship?

3. Can you provide examples of successful entrepreneurs who have made significant contributions to society?

4. Explain the traits that collectively contribute to the entrepreneurial mindset and success.

5. What are the different stages of entrepreneurship? Explain in detail.

6. What are the primary differences between micro, small, medium and large enterprises?

ANSWERS TO INTEXT QUESTIONS

23.1

1. b) Autonomy and independence
2. b) By aligning personal passions and interests with business pursuits
3. d) Job creation
4. c) By addressing societal needs and developing new solutions
5. c) By attracting investment and fostering competition

23.2

1. a) Initiative and drive
2. a) Persistence

23.3

1. d) Feasibility analysis and market research
2. d) Setting up operations and officially launching the venture
3. b) Growth and scaling

23.4

1. d) More than 250 employees
2. a) Micro enterprise

23.5

1. c) Risk-taking and problem-solving
2. d) Constant learning and adaptation
3. c) Provide guidance and open doors to opportunities

Notes

GLOSSARY

Entrepreneur: An entrepreneur is someone who organizes, manages and assumes the risks of a business or enterprise.

Entrepreneurship: Entrepreneurship is the practice of starting new enterprises, generally in response to identified opportunities.

Large enterprises: These are the largest enterprises in terms of size and often have a substantial market presence. They employ more than 250 employees and typically possess significant assets and annual turnover.

MSMEs: MSMEs (Micro, Small and Medium enterprises) are engaged in the manufacture, processing, and production of commodities and goods. The concept of MSMEs was first introduced by the Government of India and classified based on investment and annual turnover.

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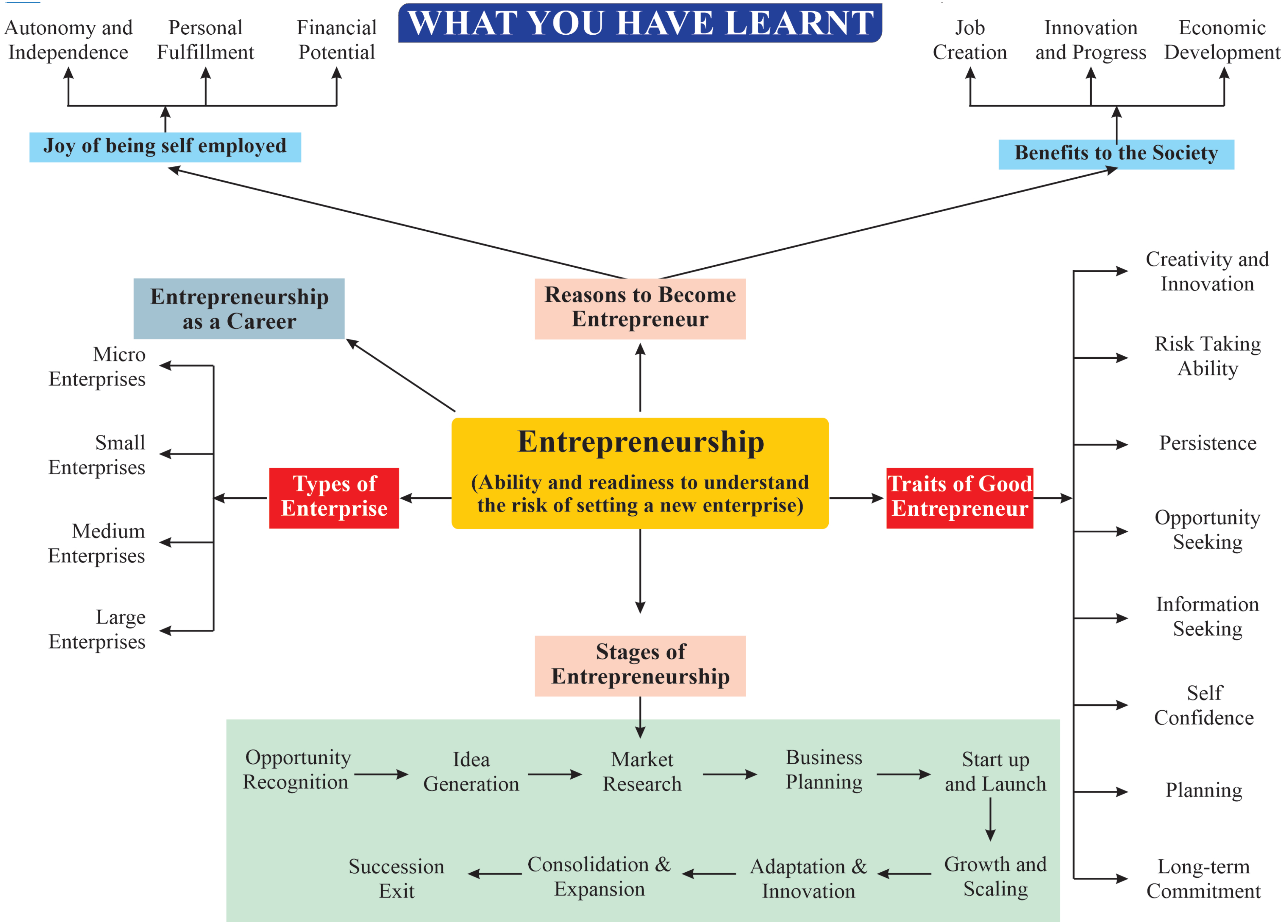

24

383KRISHICH24

IMPORTANCE OF SELF-HELP GROUPS IN AGRICULTURE AND VILLAGE ECONOMY

In the previous lesson, you learnt about the concept and meaning of entrepreneurship. You have also seen the important characteristics of a successful entrepreneur. However, it's obvious that a single individual alone may not possess the full spectrum of skills necessary to establish a successful and thriving enterprise. The real strength lies in the synergistic efforts and collectivisation of like-minded individuals with a strong drive and high achievement motivation. In this context, self-help groups play a crucial role in fostering entrepreneurship. SHGs serve as catalysts by providing a supportive environment, facilitating skill development, promoting financial inclusion, and creating a platform for collaboration and resource sharing among aspiring and seasoned entrepreneurs. In this scenario, Self-help Groups (SHGs) have emerged as promising avenues for enhancing farmers' income.

LEARNING OUTCOMES

After studying this lesson, the learner:

- explains the concept and meaning of self-help groups;
- appraises the merits of forming self-help groups among local people;
- describes the evolution of SHGs over time; and
- persuades the local youth and women to form self-help groups for their socio-economic development.

24.1 WHAT IS SELF-HELP GROUPS (SHGS)?

Self-Help Groups (SHGs) represent collectives or community-based organisations, wherein individuals unite voluntarily with the aim of addressing common socio-economic

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issues, improving their livelihoods and enhancing their quality of life. Typically originating as small assemblies of rural individuals, SHGs emerge when community members, recognizing shared challenges, opt to unite voluntarily to uplift their socio-economic circumstances. These groups may take on either a formal, registered structure or remain informal. As defined by NABARD, SHGs consist of 20 or fewer individuals from similar socio-economic backgrounds who converge to tackle common issues by forming their own support networks. Presently, India boasts approximately 83 lakh SHGs, primarily comprising members from local villages.

The idea encompasses the values of saving, lending, and mutual assistance, with SHGs typically operating under self-regulation and peer oversight, promoting financial inclusivity. These groups play a significant role in institutionalizing women's economic autonomy. Typically, SHGs operate informally and voluntarily. In the early 1990s, banks were authorized to establish savings accounts for SHGs, facilitating economic empowerment.

24.2 NEED OF SELF-HELP GROUPS

Self-Help Groups are voluntary assemblies aimed at achieving shared objectives, uniting individuals of similar social and economic backgrounds, or traditional occupations to pool and administer resources for mutual benefit. The existence of robust community networks within Indian villages is a key factor in facilitating credit connections in rural regions, fostering the growth of SHGs. These groups serve as pivotal avenues for providing financial access to impoverished communities, thus significantly contributing to poverty reduction efforts. Additionally, SHGs play a pivotal role in empowering women from financially disadvantaged backgrounds by facilitating the development of social capital. Enhancing financial freedom through self-employment arenas not only contributes to economic empowerment but also leads to advancements in other developmental aspects, including literacy rates, healthcare quality, and family planning initiatives.

INTEXT QUESTIONS 24.1

1. What is the objective of formation of SHGs?
2. What role can SHG play in curbing the activities of money lenders in villages?
3. Which one is 'not true' from the following?
   a. SHGs are a model for imparting education.

b. SHGs play an important role in empowering women.

c. SHG is a voluntary association of people, formed to attain a collective goal.

d. Usually, SHGs are voluntary groups, with informal structure.

ACTIVITY 1

Visit a SHG in your nearby village. Enquire about the different activities being performed by the SHG.

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24.3 CHARACTERISTICS OF SELF-HELP GROUPS

Self-help groups help to improve the quality of the lives of the impoverished and poor sections of society. The common characteristics of these SHGs are as follows:

- **Shared Goals:** Individuals sharing similar social and economic backgrounds within a village come together, often with the help of non-governmental organizations (NGOs) or government agencies, to address local challenges, conflicts, and enhance living standards. SHG members commit to regular savings and collectively contribute to a shared fund, thereby reducing reliance on village moneylenders for emergency loans.

- **Voluntary Participation:** People join voluntarily in SHGs based on their common cause and interest. No one is pressurised for participation in these groups.

- **Peer Support:** Members consent to utilize the pooled resources, including grants and loans from banks, to undertake self-help initiatives or provide small loans to members in need, based on group consensus. Popular activities for SHGs include producing value-added goods such as flours, pulses, ground spices (chilly, turmeric, coriander powder), *papad*, pickles, jams, squash, etc; packaging and branding of gur, ghee, honey, etc.; creation of decorative bamboo items, etc., which are then sold under the SHG's banner.

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- **Skill Development:** SHGs facilitate their members to adopt new skill, expertise and experiences for capturing new opportunities in market.
- **Empowerment of Members:** The dissemination of technology through SHGs benefits both farming and non-farming communities on a significant scale. Members learn the recommended and standardized ways of production, packaging, drying, storage technique, selling and keeping accounts. These groups include members from economically disadvantaged backgrounds, and have the potential to enhance their income-earning capacity.

ACTIVITY 2

Collect SHG products and give their brief discussion in your own language.

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24.4 THE RISE OF SHGS: EMERGENCE AND EVOLUTION IN INDIA

- Since their inception, SHGs have been operating in villages where essential services such as banks, businesses, and retail outlets are scarce. The inception of Self-Help Groups (SHGs) in India can be linked to the establishment of the **Self-Employed Women's Association (SEWA)** in Gujarat in **1972.**
- Prior to the formal establishment of SHGs, there were early initiatives towards establishment of self-help organisations. An instance of this occurred in **1954** when **the Textile Labour Association (TLA)** in Ahmedabad established its **women's wing.** The aim was to provide training to women from mill workers' families in various skills like sewing and knitting.
- **Ms. Ela Bhatt, the founder of SEWA,** mobilised impoverished and self-employed female workers including weavers, potters, craftsmen, hawkers, etc. from the unorganised sector for the formation of SHGs. Her goal was to uplift their economic status by increasing their incomes.
- In **1992,** NABARD (National Bank for Agriculture and Rural Development) initiated the **SHG-Bank Linkage Project,** now recognized as the world's largest microfinance project. NABARD pioneered an innovative approach to this

movement with a pilot project introduced in 1991. Subsequently, starting from 1993, NABARD collaborated with the Reserve Bank of India to provide savings bank accounts to SHGs.

INTEXT QUESTIONS 24.4

1. The organization which supports mostly the development of SHGs in the country is:

   a. NGO (Non-Governmental Organization)

   b. NABARD (National Bank for Agriculture and Rural Development)

   c. ICAR (Indian Council of Agricultural Research)

   d. Ministry of Education

2. Who was the founder of Self-Employed Women's Association (SEWA)?

3. Formation of SHGs was started from ………………… state.

4. Other than agriculture, which are the other sectors in which SHGs are active?

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24.5 DEVELOPMENTAL STAGES OF SELF-HELP GROUPS IN INDIA

Each SHG generally follows these steps of evolution:

1. Formation of group
2. Capacity building of the group members
3. Savings and credit activities
4. Linkage with formal institutionalised financial institutions
5. Livelihood promotion and generating income through collective action
6. Networking, mobilisation, expansion and formation of federation

Several groups are formed with the help of self-help promoting organisations. Due to its benefit towards local institution building, Government launches campaign to mobilize women for SHGs as a social movement in different states and union territories of India.

The different types of Self-help promoting organisations are:

1. Non-governmental Organisations (NGOs)
2. Government projects
3. Poverty management programmes
4. State & commercial banks
5. Microfinance institutions
6. SHG Federations
7. SHG leaders/Entrepreneurs
8. International donor projects

ACTIVITY 3

Discuss the schedule of monthly activities of any self-help group located in your area.

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24.6 FUNCTIONS OF SELF-HELP GROUPS

SHGs deliver important functions for betterment of society. Some of the functions are enlisted, as below:

- SHGs play a significant role in fostering and developing small-scale micro-enterprises aimed at generating income.
- They aim to enhance the functional capacity of economically disadvantaged and marginalised segments of society in areas of employment and income-generation. Besides contributing towards the economic development, these groups are important for social networking.
- They provide loans without requiring collateral security from individuals who typically face challenges in securing loans at high interest rates from traditional money-lenders.

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- **Financial Inclusion**- SHGs incentivize banks to lend poor and marginalized sections of society due to the assurance of returns and the collective responsibility maintained within the group.
- They introduce the habit of money saving and its best possible utilisation by prioritisation of needs and wants.
- They also play a role in conflict-resolution through collective leadership and mutual discussions**.** They provide a platform to share experiences and provide mutual support.
- They conduct vocational training programmes for competency building and entrepreneurship development, which aim to provide livelihood opportunities for their members.
- They encourage the development of potential micro-enterprises at the village or block level by facilitating access to financial services such as savings, credit and insurance.
- **Empowering the Marginalised**– SHGs have provided a platform for the empowerment of marginalized and voiceless segments of society, granting them a voice that was previously unheard.
- **Social Integrity**– SHGs contribute to the eradication of various social ills, including dowry, alcoholism, and early marriage, by fostering community support and empowerment among their members.
- **Gender Equality** – SHGs focus on providing employment opportunities through training, thereby generating income and employment. By empowering women, SHGs contribute to advancing true gender equality in the nation.
- **Pressure Groups** – SHGs serve as pressure groups capable of exerting influence on the government to address significant issues.
- **Effective Implementation of Government schemes**– SHGs contribute to the effective implementation of government schemes and enhance their efficiency. Additionally, they play a pivotal role in combating corruption through the conduct of social audits.

INTEXT QUESTIONS 24.3

1. In what ways do Self-Help Groups (SHGs) provide support to their members for social causes?
2. How do Self-Help Groups (SHGs) derive financial benefits from their operations?
3. SHG supports in setting up of .... level enterprises.

24.7 CONSTRAINTS OF SELF-HELP GROUPS (SHGS)

Although self help groups have huge potential for socio-economic improvement of farmers in India, presently they are not performing as per the expectations. The probable reasons for this are:

- The idea of SHG has not yet reached to the poorest families of our country.
- Prevalence of patriarchal mindset in society prevents many women from coming forward to join self-help groups.
- Expanding banking facilities is crucial, given the disparity between the number of bank branches and villages in rural India.
- The sustainability and operational quality of these groups have raised concerns.
- SHGs sometimes encounter internal conflicts stemming from power struggles. Establishing monitoring bodies for SHGs nationwide could help mitigate such issues.
- SHGs operate on mutual trust, but if this trust is compromised, members may perceive their deposits as insecure or feel cheated, if not adequately informed about critical decisions. This could lead to the collapse of the SHG system.

24.8 FUTURE COURSE FOR EFFECTIVE SELF-HELP GROUPS

Currently through the active efforts of **Ministry of Rural Development** under the **Deendayal Antyodaya Yojana (DAY)** and **National Rural Livelihoods Mission (NRLM),** approximately 9 crore households have been mobilized into SHGs. Following measures may be adopted for efficient management and proper administration of SHGs:

1. The government ought to enhance its efforts to foster the expansion and advancement of the SHG movement nationwide, assuming the facilitator and advocacy roles.

2. The SHG movement needs to extend its reach to credit-deficient regions across the country, including areas like Madhya Pradesh, Uttarakhand, Rajasthan, and the states of North-East India. The Government of India is envisaging an expansion of the SHG initiative to encompass 1 crore groups, involving approximately 10 million women in the near future. The concept of SHG federation has started in different states of India to function for networking, coordination, capacity building and supporting the SHG movement as apex organization.

3. There is a pressing need to strengthen the financial infrastructure, including institutions like NABARD, Commercial Banks, and also leveraging the information technology (IT) structure for establishing improved communication network.

4. There is a crucial need to extend the reach of Self-help Groups to urban and peri-urban areas, considering the rapid pace of urbanization and the prevalent financial exclusion among the urban poor.

5. Establish SHG monitoring cells in each state for better oversight and evaluation of SHG activities.

INTEXT QUESTIONS 24.4

1. Which Government schemes target the formation of SHGs?

2. What is the function of SHG federation?

24.9 SELF HELP GROUPS IN INDIA

24.9.1 Self-help groups in remote forested villages in India

There are more than 1.2 lakhs of Joint Forest Management Committees (JFMC) in different states of India. In all the JFMCs, the respective State Governments have started SHG formation through local women to support villages located in and around the forest areas. Such SHGs deal with the processing, value addition and marketing of Non-timber Forest Products (NTFPs) including the medicinal plants. Such JFMC related SHGs have been active in the states of Chhattisgarh, Madhya Pradesh, Telangana, Uttar Pradesh, Rajasthan, West Bengal and Uttarakhand.

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24.9.2 Watershed Management Committees in India

At the village level, watershed management committees establish SHGs to foster agricultural development, embracing principles of organic cultivation and vermi-composting. These groups, comprising micro-entrepreneurs with similar backgrounds, voluntarily pool funds for mutual assistance.

24.9.3 Kudumbashree in Kerala

Initiated in 1998 in Kerala, the Kudumbashree project aims to combat poverty through community action. It stands as India's largest women-empowerment endeavour, overseen by the government. The project encompasses three pillars: microcredit, entrepreneurship, and empowerment.

24.9.4 Mahila Aarthik Vikas Mahamandal (MAVIM) in Maharashtra

In Maharashtra, SHGs faced challenges managing increasing transactions, prompting the establishment of Community Managed Resource Centre (CMRC) under MAVIM. CMRC offers sustainable financial and livelihood support tailored to SHG needs. The mission of MAVIM is to enhance women's access to education and boost their involvement in decision-making and governance to bring social equity.

It also plays crucial role in strenghtening women's entrepreneurship skills and improving their access to credit and markets.

ACTIVITY 4

Visit a cooperative or nationalized bank to inquire about the presence of Self-Help Groups and their initiatives.

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WHAT YOU HAVE LEARNT

- Self-Help Groups (SHGs) are informal collectives where individuals unite to address their common concerns/issues and enhance their living standards. They operate autonomously and are governed by members.
- Self-help Groups (SHGs) are driving force for women unity, solidarity and promotion of local level enterprises.
- Self help groups are characterized by their shared goals, voluntary participation, informal organizational structure, peer support, skill development initiative and empowerment of members.
- Key functions of SHGs are encouragement of saving among the poor, supply of collateral-free loans, and financial inclusion.

TERMINAL QUESTIONS

1. Discuss the key functions of Self-Help Groups.
2. What are the unique characteristics of SHGs?
3. How SHGs can help in the social development process?
4. Why SHGs are more active and have larger spread in rural areas?
5. What are the constraints plaguing the SHG programme in our country?

ANSWERS TO INTEXT QUESTIONS

24.1

1. SHGs are formed for economic empowerment of the members and to overcome the common issues and challenges.
2. SHG members save their money on regular basis through which they set up small business at local level. From the saved amount, they can provide interest free loan to their members, which protects them from the high interest rates of money lenders.

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3. Option a

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1. NABARD
2. Ms. Ela Bhatt
3. Gujarat
4. Weaving, pottery, forest product processing, craft manufacturing

24.3

1. They play a role in conflict resolution through collective leadership, mutual discussions and empowerment.
2. SHGs support individuals in earning a livelihood by providing vocational training and facilitating access to tools and resources. They provide loans without requiring collateral to individuals who typically face challenges in securing loans from traditional banking institutions.
3. Micro

23.4

1. Deendayal Antyodaya Yojana (DAY) and National Rural Livelihoods Mission (NRLM)
2. SHG federation acts as apex organisation of self-help groups. Its function is networking and coordination among SHGs, capacity building and supporting the SHG movement.

GLOSSARY

Empowerment: An act or process of enabling individuals to give authority and power to perform and achieve the results they desire.

Microcredit: It is a small loan facility provided to the low-income individuals or groups without collateral, to motivate them to start their business and become self-employed. It is offered by microfinance institutions (MFIs), non-governmental organizations (NGOs), or banks that cater to needs of marginalized populations.

Unorganized sector: The segment of economy where economic activities are undertaken by individuals or private enterprises without formal registration. They are

characterized by low levels of organization, limited access to social security benefits, and operate outside the purview of government regulations.

SUGGESTED READINGS

1. Non-government organisation (NGO) and self-help group, TNAU Agritech Portal, Tamil Nadu Agricultural University, Coimbatore, India.

   (https://agritech.tnau.ac.in/ngo_shg/shg_intro.html)

2. A Handbook on Forming Self-Help Groups (SHGs), National Bank for Agriculture and Rural Development (NABARD), Mumbai.

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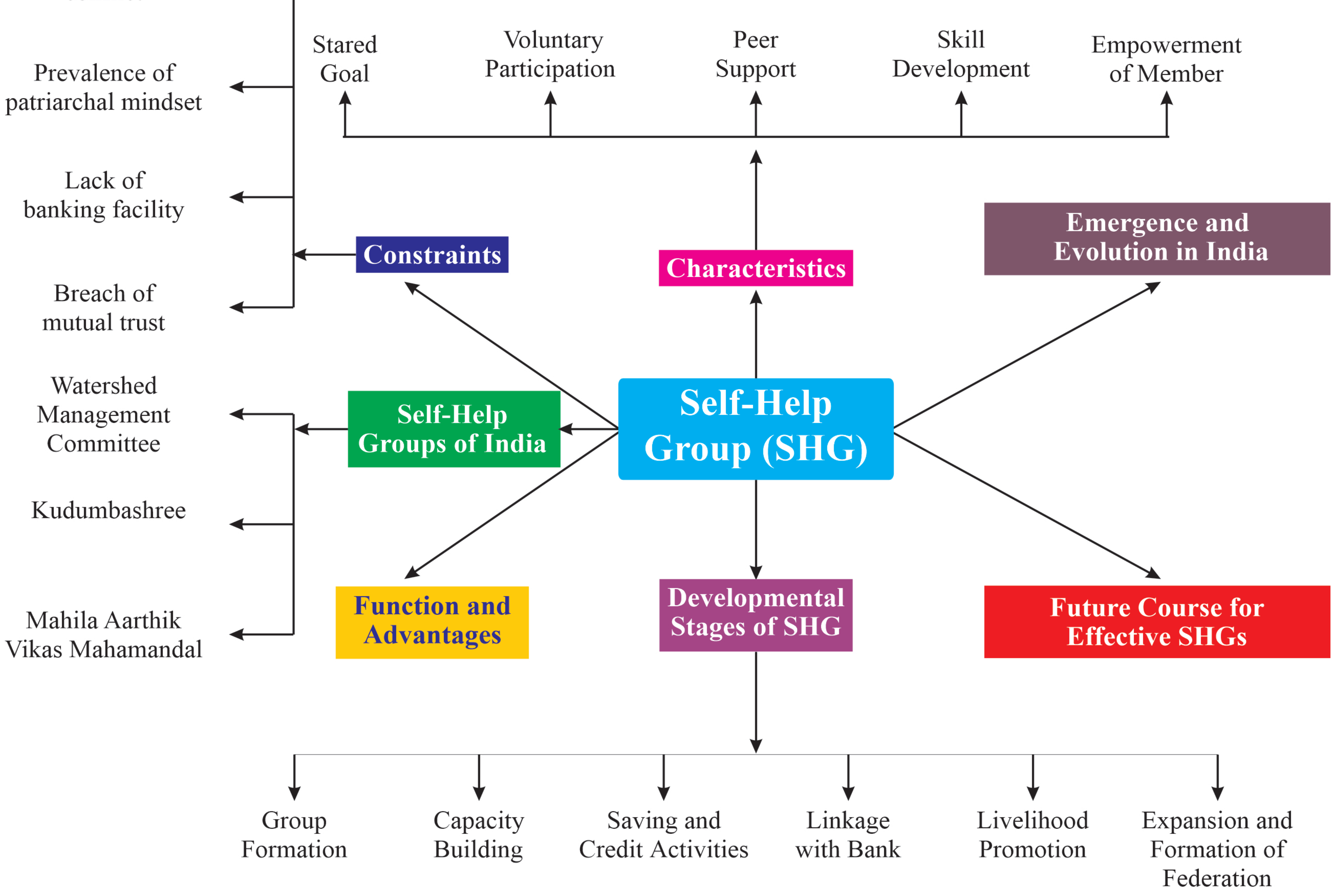
WHAT YOU HAVE LEARNT



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CAREER OPPORTUNITIES IN AGRICULTURE SECTOR

In the previous lessons, you learned about the importance of agriculture in the growth and development of our country. You also explored how new technologies can help address some of the major challenges faced by this sector. Trained professionals in these emerging technologies are required to transform the farming sector. The field of agriculture is vast, offering professionals various opportunities to work in sectors such as crop production, crop protection, marketing and sales, farm engineering, farm management, academia and research, or entrepreneurship. After graduation, you may choose from a wide range of career opportunities within agriculture and allied sectors.

LEARNING OUTCOMES

After studying this lesson, the learner:

- recognizes the employment opportunities in the field of agriculture;
- identifies agriculture related educational programmes available in India; and
- explains the roles and responsibilities of popular professions of the agriculture field.

25.1 AGRICULTURE: AS A PROFESSION

When India gained independence, the then Prime Minister of India Pandit Jawaharlal Nehru, stated, "**Everything else can wait, but not agriculture**". This statement was reaffirmed during the Covid-19 pandemic in 2019-2020, while all other sectors of the economy halted, but agriculture continued at its pace, as food is a necessity and we rely on it daily.

In addition to final consumption, agricultural outputs serve as raw materials for various industries. The commercialization of agriculture calls for specialized production, post-harvest management, and the expansion of processing, storage, transportation, packaging, and marketing operations, both domestically and internationally. However, in India, about 20-30% of crops are wasted annually due to improper handling, spoilage, floods, droughts, pests,diseases, and lack of knowledge of post-harvest technology. Certain sectors, such as floriculture, aquaculture, poultry, fruits and vegetables are especially vulnerable to these problems. Therefore, professionals with advanced scientific knowledge and management skills are in high demand throughout the world.

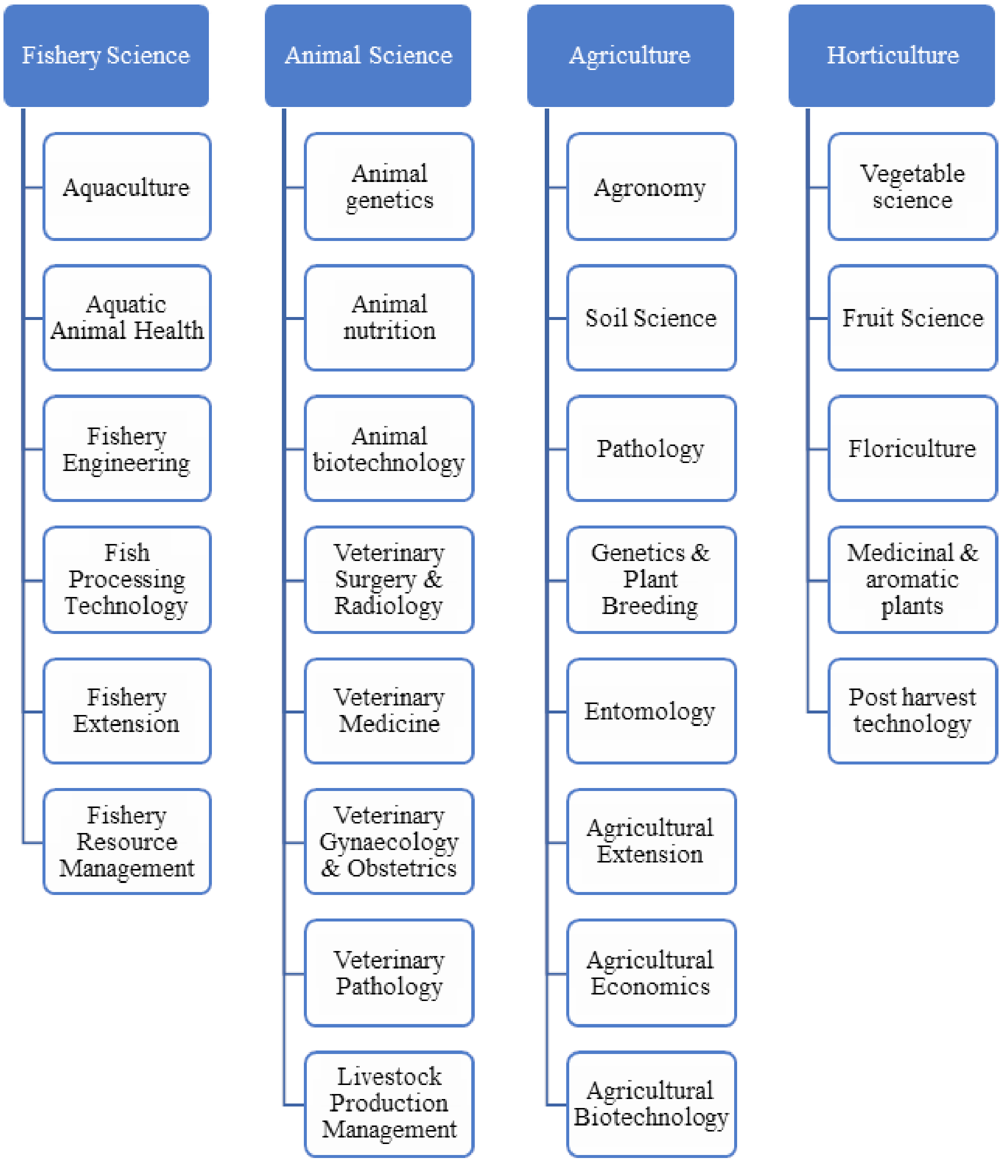

Fig. 25.1: Major divisions of agricultural and allied sciences

If you are interested in a career in agriculture,you may explore the various lines of employment in agriculture and the skills needed to succeed in these roles. Career paths may involve activities ranging from crop production to large scale plantations, manufacturing bio-fertilizers and bio-pesticides, or raising livestock like cattle, pigs, poultry and fish. There are several branches of agricultural science, like crop science, horticulture, biotechnology, water management, economics and marketing, agronomy, soil science, pathology and entomology, etc. Similarly, allied fields like animal sciences cover disciplines suh as dairying, animal husbandry, rearing of sheep and goat, animal diseases, animal feed and fodder, animal biotechnology, poultry, fisheries, apiculture and sericulture.

New avenues are emerging through innovations and reforms in agriculture, leading to increased production and optimized benefits. Our country needs professionally qualified individuals who understand technological advancements to tackle the challenges in this sector.

25.2 EDUCATIONAL PROGRAMMES AVAILABLE IN AGRICULTURE SCIENCE

Formal education in agriculture can provide you a fulfilling career in agriculture. In India, there are numerous government and private universities offering undergraduate, post-graduate, and doctoral degrees in agriculture. After completing school education, you can pursue a bachelor’s degree in agriculture or related disciplines. Some of the educational programmes available at the undergraduate level are mentioned in the table below.

Table 25.1: Undergraduate courses offered in agriculture and allied disciplines

Bachelor of Science (B.Sc.) in Agriculture	B.Sc. in Horticulture	B.Sc. in Forestry
B.Sc. in Animal Husbandry	B. V. Sc. (Bachelor in Fishery Science)	B.F.Sc. (Bachelor in Veterinary Science)
Bachelor of Technology (B.Tech.) in Agricultural Engineering	Bachelor of Technology (B.Tech.) in Dairy Technology	Bachelor of Technology (B.Tech.) in Food Technology
Bachelor of Technology (B.Tech.) in Plant Biotechnology	B.Sc. in Tea Husbandry and Technology	B.Sc. in Community Science

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B.Sc. in Sericulture	B.Sc. in Food Nutrition & Dietetics	Bachelor in Agribusiness Management

Most of the professional courses listed are of four year duration (except B.V.Sc.) are offered by agricultural universities across India. Currently, there are 63 state agricultural universities accredited by the Indian Council of Agricultural Research (ICAR) (https://www.icar.org.in/state-agricultural-universities). In addition to state agricultural universities (SAUs), several other universities run by Govrnment of India offer agricultural programs. These can be categorised as deemed universities, central agricultural universities, and central universities with agriculture departments.

Deemed Universities:

1. ICAR-Central Institute of Fisheries Education, Mumbai
2. ICAR-Indian Agricultural Research Institute, New Delhi
3. ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh
4. ICAR-National Dairy Research Institute, Karnal, Haryana

Central Agricultural Universities:

1. Central Agricultural University, Imphal, Manipur
2. Dr. Rajendra Prasad Central Agricultural University, Samastipur, Bihar
3. Rani Laxami Bai Central Agricultural University, Jhansi, Uttar Pradesh

Central Universities with Agriculture Departments:

1. Aligarh Muslim University, Aligarh, Uttar Pradesh
2. Banaras Hindu University, Varanasi, Uttar Pradesh
3. Nagaland University, Lumami, Nagaland
4. Vishwa Bharti University, Shantiniketan, West Bengal

After completing an undergraduate degree (B.Sc./B.Tech./B.V.Sc./B.F.Sc.), students can pursue postgraduate degrees (M.Sc./M.Tech./M.V.Sc./M.F.Sc.), and a PhD (Doctor of Philosophy) invarious sub-disciplines. These advanced degrees can lead to teaching and research-oriented careers. Candidates with higher academic qualifications and relevant work experience may find employment with reputed national and international institutions.

DO YOU KNOW

Indian Institute of Technology, Kharagpur is the only IIT in the country that offers a B.Tech. degree in agricultural engineering.

ACTIVITY-1

You can explore the list of agricultural universities in India by following this link: https://icar.org.in/state-agricultural-universities. Check whether there are any agricultural universities located in your state.

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National and International Recruiting Agency

Several national and international organizations recruit agriculture graduates and post-graduates in various roles for leveraging their diverse skill sets in the field of to food production, environmental sustainability, and rural development. These national organizations include

- Indian Council of Agricultural Research (ICAR)
- Indian Council of Forestry Research and Education (ICFRE)
- Indian Space Research Organization (ISRO)
- Defence Research & Development Organisation (DRDO)
- Food Corporation of India (FCI)
- Agricultural & Processed Food Products Export Development Authority (APEDA)
- Food Safety and Standards Authority of India (FSSAI)
- Ministry of Agriculture and Farmers' Welfare
- Ministry of Fisheries, Animal Husbandry and Dairying

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- Ministry of Rural Development
- Commercial banks
- National Bank for Agriculture and Rural Development (NABARD)
- Central Silk Board
- Tea Board of India
- Coffee Board of India and others

Some prominent international agriculture organizations which provide opportunities to work for sustainable agricultural practices, food security, and rural development are:

- Food and Agricultural Organization (FAO), Rome, Italy
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India
- International Rice Research Institute (IRRI), Los Baños, Philippines
- International Maize and Wheat Improvement Center (CIMMYT), Mexico
- International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria
- International Water Management Institute (IWMI), Colombo, Sri Lanka
- International Livestock Research Institute (ILRI), Nairobi, Kenya
- The International Center for Agricultural Research in the Dry Areas (ICARDA), Beirut, Lebanon
- International Potato Center (CIP), Lima, Peru
- The World Vegetable Center, Taiwan

Management Programmes in Agriculture Sectors

After graduating in agricultural and allied sciences, you can also pursue an MBA (Master of Business Administration) or PGDM (Post-Graduate Diploma in Management) with a specialization in Agribusiness Management to build capacity for managing the agribusiness sector. These are two-year courses, offered by many agricultural universities, as well as autonomous public and private business schools. Some of the renowned institutes in India offering degrees in agribusiness management are:

1. Indian Institute of Management (IIM), Ahmedabad
2. Indian Institute of Management (IIM), Lucknow
3. National Institute of Agricultural Extension Management (MANAGE), Hyderabad
4. National Institute of Agricultural Marketing (NIAM), Jaipur
5. National Academy of Agricultural Research Management (NAARM), Hyderabad
6. Institute of Rural Management (IRMA), Anand, Gujarat

Short Term Courses

If formal education in agriculture sector is not feasible for you, you may consider opting for various short term courses, workshops, or training programmes offered by agricultural universities, open universities, Krishi Vigyan Kendras (KVKs) or the Department of Agriculture under the state or central government. These courses can be especially useful for those interested in pursuing agri start-ups or agri enterprises. The National Institute of Open Schooling (NIOS) also offers several vocational courses in different disciplines of agriculture, aimed at building practical competencies, knowledge,and values among students from a young age. Below is a list of short term courses offered by NIOS:

List of offered courses (https://www.nios.ac.in/)

1.	Mushroom Production	2.	Vermicomposting
3.	Bee Keeping	4.	Paddy Farming
5.	Poultry Farming	6.	Bamboo Cultivation
7.	Plant Protection	8.	Soil and Fertilizer Management

INTEXT QUESTIONS 25.1

1. Give examples of any three undergraduate programmes for pursuing a career in the agriculture sector.

2. If you want to become a veterinary doctor, the preferable undergraduate degree would be:

   a. B.Sc. in Agriculture

   b. B.Sc. in Sericulture

   c. B.Tech. in Dairy Technology

   d. Bachelor in Veterinary Science

3. In India, the duration of the 'Bachelor in Agricultural Science' course is ....

25.3 POPULAR JOB OPPORTUNITIES IN AGRICULTURE SECTOR

A. Agri-entrepreneur

Entrepreneurs are individuals who develop and manage their businesses to earn profits. In the agriculture sector, they can venture into various fields such as apiculture, fishery, mushroom cultivation, vermi-composting, and the cultivation of medicinal and aromatic plants. Selling vermi-compost products is also a viable option. Additionally, the nursery business in urban areas has become a profitable avenue for agriculture professionals. Agri-entrepreneurs design new tools, equipment, technologies, and strategies for agricultural applications in alignment with government policies, schemes, and focus areas.

Success story of an agri-entrepreneur:

Mr. Srikant Singh is a farmer from Khakhra village in Aurangabad, Bihar. His family has been involved in agriculture for several generations. He manages approximately 3 hectares of land, equipped with modern irrigation systems like drip and sprinkler, and earns a modest income from his agricultural activities.

To increase his income, Mr. Singh decided to venture into vermicompost production.This process involves the decomposition of organic material by earthworms. While cow dung is commonly used as the primary input, other agricultural wastes can also be utilized. For this purpose, specialized pits are created and the earthworms take around 45-50 days to decompose the material and produce vermicompost.

Mr. Singh attended a training program at the Krishi Vigyan Kendra (KVK) in

Aurangabad district, where he learned the techniques for producing high-quality vermicompost.

After completing the training, he actively engaged in vermi-compost production, digging 135 pits and fillingthem with cattle dung. The expenditure for creating these pits was approximately ₹2,53,800/-. He earned ₹ 3,94,200/- from selling vermi-compost to the state agricultural department.

Generally, the production cost for 1 kg of vermi-compost is around ₹ 4-5, and it is sold in the market at ₹ 10-12/kg. In the year 2022, he supplied 400 quintals of vermi-compost and has providedemployment to 4-5 rural men and women in his village.

Fig. 25.2: Vermicomposting unit of Mr. Srikant Singh

Success story of an inspired Tassar silk cocoon grower of Bihar:

Mr. Dhanu Singh, a resident of South Bhorsar village in the Katoria block of Banka district, Bihar, has been involved in his family's Tassar silk cocoon production business for generations. The rearing of the cocoons occurs biannually, from July to September and from September to December, each cycle lasting approximately 45 days. During this period, the silk larvae undergo five moulting stages. The first and second moulting stages occur on one plant within 5-6 days, while the larvae are moved to another plant for the third and fourth moulting stages, which occur within 3-4 days. The fifth moulting stage takes place within 12 days.

PRADAN and NGOs at the district level provide assistance for plantation and Tassar seed procurement. They offer a Tassar seed packet (200 grams) priced at Rs. 1,600/-, containing approximately 20,000-22,000 eggs, from which approximately 9000-10000 cocoons can be reared. Typically, 2-3 packets of seeds are required annually for cultivation. The Tassar plants are spaced approximately 5 meters apart for commercial purposes and 10 meters apart in forest areas, with each plant capable of rearing 250-300 cocoons. A total of 2,000-3,000 Tassar

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plants are used for cocoon production. A single packet of seed can produce about 4000 high grade cocoons and 5000-6000 low grade cocoons .

The market price of higher-grade cocoons varies between 7-8 rupees per piece, whereas lower-grade cocoons fetch Rs. 4-5 per piece. Additionally, the price for cocoon compost is set at Rs. 1.5 per unit. He makes an annual profit of approximately Rs. 80,000 to Rs. 100,000, from the sales of both cocoons and cocoon compost. He markets his products in local markets and nearby areas, including Bihar Sarif, Nawada, Bhagalpur, and West Bengal. He stays updated on the latest techniques and addresses production related issues by consulting with experts and extension personnel.

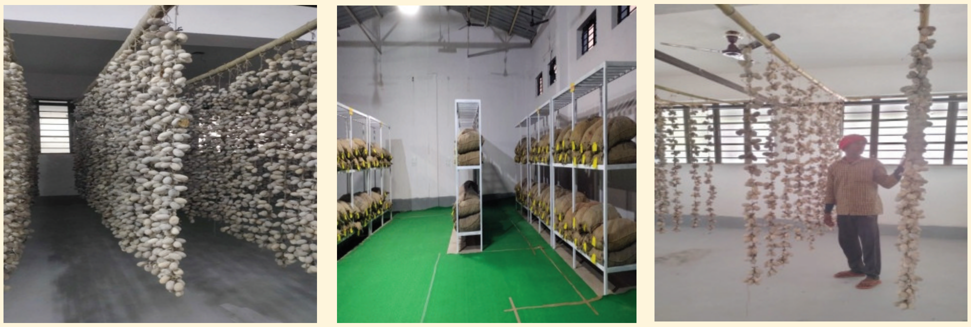

Fig. 25.3: Sericulture unit of Mr. Dhanu Singh

Success story of an inspirational mushroom grower of Punjab:

Mr. S. Sukhdev Singh, a resident of Meeranpur village in the district of Patiala, has been successfully engaged in mushroom production since 2014 . Through his hard work and dedication, he has become a source of inspiration for rural youth by developing his mushroom farm over an area of two acres. Mr. Singh initially began mushroom cultivation as a subsidiary occupation by preparing compost from 100 quintals of wheat straw. Over the subsequent years, he gained valuable experience in the field of mushroom production and transitioned to the short method of composting, by obtaining a 40% subsidy on his composting unit from the Department of Horticulture, Government of Punjab.

Mr. Singh constructed a bunker and a pasteurization chamber/tunnel with a capacity of 30 tonnes for preparing compost for button mushroom production. The compost produced through this method is of superior quality and free of diseases, resulting in greater yields compared to the long composting method. Initially, he used the compost solely for his own farm but later began preparing and selling compost to small and medium-scale growers as well as urban dwellers. This approach effectively promotes

mushroom cultivation throughout the state.To cultivate mushrooms, the farmer constructed 35 mushroom huts using paddy straw and bamboo, each with dimensions of 30' x 60' and a capacity to accommodate 2,200-2,400 bags. He effectively utilized agricultural residue from his own fields as well as from adjacent fields. Approximately one acre of paddy straw from fields is used to construct a single mushroom hut. Following recommendations from the Punjab Agricultural University in Ludhiana, the farmer prepared compost using a 1:1 ratio of wheat and paddy straw, resulting in better yields. He also provides employment to 20-30 individuals for compost making, watering, harvesting, and post-harvest care. To market his fresh produce, he sells in local markets and Ludhiana Mandi. Additionally, he cultivates summer varieties such as milky and paddy straw mushrooms on a small scale. To stay updated on current knowledge and address any mushroom-related problems, he remains in touch with experts from the Punjab Agricultural University in Ludhiana.

Fig. 25.4: Few glimpses of Mr. Sukhdev Singh's Milky mushroom cultivation

B. Agronomist

The agronomists are professionals specialized in crop production, pest control, and soil management. Several government organizations and agribusiness companies, like seed and agro-chemical companies, recruit agronomists for their research labs or field experiment stations. Their primary goal is to enhance the well-being and health of crops.

Responsibilities of an agronomist:

1. **Develop better cultivation, planting and harvesting techniques:** Agronomists seek innovative methods to improve farming practices, including

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experimenting with new planting methods, optimizing irrigation techniques, and implementing sustainable farming practices to enhance crop growth and yield.

2. **Improve crop yield:** They work to maximize the productivity of crops by identifying factors that limit growth and implementing strategies to address these issues. This may involve selecting high-yielding crop varieties, managing nutrient levels in the soil, and controlling pests and diseases that affect crop health and yield.

3. **Maintaining the quality of seed and nutritional value of crops:** Agronomists evaluate seed varieties for traits such as disease resistance, drought tolerance, and nutritional content to improve crop performance and meet consumer demands for nutritious food.

4. **Improve soil productivity:** They assess soil health, fertility, and quality to develop strategies for enhancing soil productivity and sustainability. This may involve soil testing, implementing conservation practices, and recommending appropriate fertilization and crop rotation methods to maintain soil fertility over time.

C. Soil Scientist

Such scientists conduct research both in field and laboratory to improve fertility and productivity of soil. They collect soil samples from farms to analyze nutritional needs and fertilizer requirements. A soil and plant scientist's job focuses on

- Testing soil and plant to obtain the information about nutrient status
- Improving soil health and understanding how it affects plant growth
- Researching alternative methods of growing crops to maximize crop yield
- Protecting the soil from erosion and degradation.

D. Plant Breeder

Plant breeder is a professional who specializes in the art and science of breeding plants. Plant breeding involves the controlled manipulation of plant species to produce plants with desired traits and characteristics. This process is essential for developing new and improved varieties of crops, ornamental plants, and other cultivated species.

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E. Farm Manager

In this occupation, the individual is responsible for overseeing farm operations and making strategic business decisions within budgetary constraints. Duties include managing the maintenance and repair of farm buildings and equipment, as well as marketing the farm's products. Previous experience in farming is essential, along with technical knowledge encompassing compliance with government regulations and adherence to health and safety standards. Farm managers are generally recruited by Krishi Vigyan Kendras (KVKs), agricultural universities, research institutes, and seed companies.

F. Academic /Lecturer Jobs

India has a network of 70+ agricultural universities and 100+ research institutes under the Indian Council of Agricultural Research (ICAR). These organizations recruit young scholars as assistant professors or junior scientists after completion of a Master's or PhD degree in a specialized discipline. Lecturers provide basic knowledge of agriculture and allied disciplines to students and conduct experimental research in agricultural colleges and universities.

G. Agricultural Economist

In this role, an agricultural economist applies principles of micro and macroeconomics to understand economic decisions such as

I. Determining the rationale behind producing a specific combination of food crops in a given year.

II. Strategizing resource optimization in both production and post-production stages.

III. Analyzing how government support for farmers is determined.

They collect and analyze economic data to find and determine trends in economic activity. They also develop future possible scenario through simulations based on past data, which help the policy makers in developing strategies for future.

H. Commercial Horticulturalist

A horticulturalist focuses on day-to-day activities for vegetable and fruit production process - overseeing the cultivation, harvesting, packaging, distribution and sale of fruits, vegetable flowers and plants.

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A landscape horticulturist may work with planners, architects and designers to create parks, gardens and recreational areas. They are also engaged in the maintenance of public gardens, managing fruit orchards, overseeing the production of organic fruits and vegetables.

Success story of a flower entrepreneur:

Ms. Vinod Kumari Shah is a woman entrepreneur from the village Maili, District Hoshiarpur, Punjab. She started farming with her parents after completing her higher secondary studies. Initially serving as a president of the Sandhya Self Help Group (SHG), she underwent training at KVK Bahowal with other members and was involved in activities like stitching, painting, making pickles (Achar) and chutneys. However, the returns from these endeavors were not satisfactory, prompting her to explore alternative avenues.

In 2014, an expert team from Punjab Agricultural University visited Maili village to conduct an awareness programme for a Government of India project. They interacted with Ms. Vinod Kumari Shah and encouraged her to undergo training in value-added products from vegetables and flowers. Subsequently, Ms. Shah attended hands-on training at village Maili and PAU, Ludhiana on value addition techniques for vegetables and flowers, including mixed pickles of cauliflower and carrot, black carrot Murraba, black carrot Kanji, tomato sauce and puree, Ghia chutney, rose Sharbat, and Gulkand. This marked a turning point in her life. She started producing 100% natural Rose sharbat using fresh desi rose petals sourced from local farmers in the kandi region of district Hoshiarpur. The beauty of her product is that it contains no synthetic preservatives or colours. The shelf life of this rose sharbat is about two years at normal room temperature. Ms. Vinod Kumari has been awarded with Sardarni Jagbir Kaur Memorial Award 2016 by Chief Minister of Punjab during the PAU Kisan Mela at Ludhiana, for her achievements in agriculture and allied enterprises. Due to her consistent efforts, there has been a significant increase in the sales of rose sharbat bottles (4000-5000 bottles per year), as well as other value-added products. Currently, Sandhya's SHG has about 150 associated members and generates an annual revenue of aproximately Rs. 18-20 lakhs.

I. Agricultural Engineer

Various farm machineries, tools, and equipments are required in the agriculture sector. Individuals with technical knowledge of agricultural engineering oversee the design, manufacturing and maintenance processes of machineries like tractors and harvesters. Other important roles they fulfil include:

- Planning, designing, and overseeing the construction of irrigation projects for the distribution and application of water to agricultural lands
- Developing strategies to conserve soil and water resources
- Enhancing the processing and storage of agricultural products
- Supervising the production of machinery

INTEXT QUESTIONS 25.2

1. The person who develops their own agricultural businesses and manages its operation is called
   a. Agronomist
   b. Agri-entrepreneur
   c. Farm manager
   d. Agricultural engineer
2. An agronomist works for
   a. Overall well being of crops
   b. Construction of irrigation projects
   c. Conservation of forest
   d. None of these
3. Farm managers can be recruited at ....
4. Design, manufacture, and maintenance of farm machineries are done by agricultural engineers (True/False).
5. Which professionals area engaged in the creation of parks, gardens and recreational areas?

J. Administrative Jobs

There are separate agriculture departments in both the central and state governments. Individuals with an agriculture background are often recruited as agriculture development officers, horticulture development officers, fishery

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inspectors, or livestock officers within these departments. Their primary responsibilities include:

- Enforcing government policies pertaining to agriculture
- Promoting integrated development of the rural economy through agricultural initiatives
- Developing an effective extension plan to disseminate proven and viable production technologies to the farming community
- Supervising the agricultural activities of the area under their respective jurisdictions
- Performing tasks such as book-keeping, project implementation, and accounting

K. Technical Assistant/Lab Technician

Monitoring the nutrient content of soil and plants, as well as the quality of seeds, fertilizers, pesticides, and food, is necessary for successful crop production, marketing, and human consumption. To ensure this, various government and private organizations recruit technical assistants or lab technicians who help in analyzing, examining and evaluating the quality of agricultural produce in laboratories. Their primary responsibilities include:

- Collecting field samples from different sites and assisting in the management of field and glasshouse trials
- Accurately recording data and information from research trials to ensure uniformity and quality in samples
- Conducting laboratory experiments in accordance with designated protocols
- Operating and maintaining field equipment and laboratory instruments as per the required standards

L. Agricultural Marketing and Salespersons

The agribusiness industry needs to sell its products like seeds, fertilizers, agro-chemicals, animal feed, and machinery to farmers. For this, the sellers are also required to provide advice related to product features and the benefits to be realized. Therefore, companies hire individuals with technical knowledge of agriculture for such positions. The recruits listen to the needs of the farmers and then recommend suitable products to meet their requirements.

M. Agricultural Extension Specialists

Agricultural extension specialists are village-level extension workers who serve as a conduit to transfer improved farming practices and knowledge of scientific innovations to the last-mile farmers. They act as a bridge between the laboratory and the land. They provide advice, support, and training to farmers and help improve the efficiency and productivity of farming operations. Their primary responsibilities include:

1. To monitor the production and productivity of crops in their area to maintain the base records for comparison

2. To conduct, organize and supervise demonstrations, seed village programmes, diversified cropping programmes, and introduction of new crops/varieties along with group discussions

3. To prepare situation-specific crop production plans for each farmer and assess their input requirements realistically

4. To advise on and prepare long term action plans for encouraging sustainable agricultural practices, optimal fertilizer consumption, use of bio-fertilizers, use of improved farm implements and machinery, and increasing irrigation potential through dug wells, deep/shallow tube wells, etc.

N. Plant Protection/Quarantine Specialist

It is common for plants or agricultural products to be infested with fungus, virus, bacteria, insects, weeds, mites or nematodes in field as well as in storage. A Plant Protection Specialist, also known as a Plant Health Specialist or Plant Pathologist, is a professional who specializes in safeguarding crops and plants from pests, diseases, and other environmental threats. To become an expert in plant protection, one must specialize in weed science, entomology, plant pathology or nematology. Key job aspects of plant protection specialists include:

- To direct or monitor the quarantine, treatment, or destruction of plants or plant products
- To promote integrated pest management
- To ensure the availability of safe and quality pesticides
- To streamline quarantine measures

O. Animal Doctor/Veterinarian

A veterinarian, sometimes referred to as a vet, is an animal doctor who is responsible for diagnosing and treating animals those are sick, injured, or need routine care. To be a veterinarian, one must complete a B.V.Sc. (Bachelor in Veterinary Science) degree, which is a 5.5 year course. After completing this degree, a person can be recruited in both the government and private sectors. A veterinarian can also start a veterinary pet clinic, as the number of pets is growing steadily along with the demand for their healthcare.

Fig. 25.5: Veterinarian

Success story of backyard poultry farming

Sania Tuddu, a college student from Burudih village in Saraikela, Jharkhand, faced numerous challenges during her school years. She comes from a financially struggling family that could only afford two basic meals a day. Completion of education was a great challenge for her. To finance her college education, she began working as a farm labourer. During a visit to a Kisan Mela organized in the district, she learned about backyard poultry farming, which she found to be a lucrative means to support both her family and educational expenses.

Attending training programs helped Sania to gain the necessary knowledge and skills related to improved techniques for backyard poultry farming, covering aspects like breeds, feeding, disease control, vaccination, and marketing.

In 2015, she began poultry farming with 20 Jharsim breed poultry birds provided by the agricultural university. While studying in college, she scheduled her poultry farming activities in the morning and evening. After six months, the birds started laying eggs and gained weight, with an average body weight of 3 to 3.5 kg. She collected approximately 130 eggs and sold them for ₹10 each, while the birds were sold for ₹280 per kg. With a profit of ₹12,000, she expanded her backyard poultry farming business and increased her flock size to 135 birds over the next two years.

She now earns an average annual income of ₹30,000 to ₹35,000 by selling birds and eggs. Recognizing her entrepreneurial spirit, she was invited to share her success story on the regional Doordarshan channel and radio, and was honored by the Hon'ble Governor of Jharkhand with an award.

Fig. 25.6: Ms. Sania Tudu with her poultry birds

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P. Fish Hatchery Manager

A fish hatchery is a place where young fishes are produced and reared commercially for distribution and selling to fish farms at a later period. A fish hatchery manager oversees the daily operations of a fish hatchery. A person with technical knowledge in fishery is preferred over others. Their work includes:

- Overseeing egg incubation, fish spawning, and fish rearing
- Performing hatchery operations
- Coordinating with employees
- Preparing the budget

Success story of a progressive fish farmer:

Sh. Manvender Singh, a resident of Bhurewala village in Ambala district, Haryana ventured into the fisheries sector in 2018. He reeived valuable advice and encouragement after consulting with District Fisheries Officer, Ambala. Later, he underwent training from the Fisheries Department, Haryana. In November 2018, he constructed a fish pond on two hectares of his own land. Over the time, he dug three more small ponds for nursery. For the construction of fisheries farm (digging of ponds, construction of office and store room, seed, medicine, equipment, aerators and feed), he spent a total of Rs. 15 Lakhs. He received a financial subsidy of Rs.5.37 lakhs towards pond excavation and inputs assistance from the Fisheries Department, Haryana.

In year 2020, Mr. Singh procured one lakh fish seeds from the Fisheries Department and stocked them in the nursery pond. After a couple of weeks, the fingerlings were transferred to the main pond. By the end of the same year, he sold 20 tonnes of fish. In that year, his earnings from fish farming were Rs. 20 lakhs, with a net profit of approximately Rs. 12 Lakhs. He plans to develop more ponds to boost fish production in the coming years.

Fig. 25.7: Fisheries farm of Mr. Manvender Singh

Q. Forest Conservationist

A person with training in preservation, protection, and management of forests and other natural areas is a forest conservationist or forester. Another vital aspect of a forester's role is the conservation of wildlife habitats within forests. Therefore, knowledge and capacities for management of forest, the environment, and wildlife are crucial for a forester. They work in partnership with government agencies, landowners, and environmental groups. After graduation, you can appear for Indian Forest Service (IFS) or State Forest Service (SFS) exams to become a forester in central and state forest departments.

R. Food Inspector/Food Safety Officer

Food inspectors are experts in public health who verify that food items adhere to safety and labelling regulations. They also guarantee the cleanliness and safety of the food supply. Generally persons with degrees in biological sciences such as agriculture, food science/food technology, botany, zoology, microbiology or biochemistry are preferred as food inspectors. Their main duties include:

- To take samples of any food or substance which appears to have been sold for human consumption
- To inspect any place where the food is manufactured or stored for sale

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- To check for the manufacturing or storage of any adulterants and take samples of such food or adulterants for analysis

S. Dairy Manager

Depending on the size and kind of dairy farm, a dairy manager's duties can vary, but in general, they are in charge of managing the daily operations of the dairy. To become a dairy manager, one must complete training in dairy technology. Some common responsibilities associated with a dairy manager include:

- Animal care
- Managing the milking operation
- Quality control of milk
- Staff management
- Maintaining records of animal health, production and breeding
- Maintenance of dairy instruments

Success story of a dairy farm:

Located just a few kilometers from the National Dairy Research Institute (NDRI) in Karnal, Haryana, lies the quaint village of Nalvikhurd, surrounded by lush green wheat and berseem fields. Among the several commercial dairy farms in the area, Arvind Dairy Farm stands out. Owned by Mr. Parmod Khokhar and his brother Mr. Ravi Khokhar, the farm has a rich history of traditional farming.

Fig. 25.8: Arvind Dairy Farm of village Nalvikhurd

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Although the family has traditionally pursued farming, it was only five years ago that Mr. Khokhar decided to diversify the farm by rearing crossbred dairy animals. The farm currently houses 80 crossbred cattle (Holstein Friesian cross) along with an automated milk collection system and a meticulously maintained cattle shed and feeding area. The animals are fed high quality forages like a mixture of green and dry fodder (berseem, oats, and wheat straw), homemade concentrate (maize/wheat/barley + deoiled cake + neem) and mineral mixtures to ensure good health and high-quality milk production. Proper and timely vaccination is administered to maintain the sound health of the animals. Mr. Khokhar reports milk yields of 35-53 liters per day and average annual profit of 47 lakhs from his farm.

Currently, the farm supplies milk to big companies like Nestle, nearby villages, local sweet shops, and community functions as needed. The farm has also sold around 50-60 animals and provides advice on dairy farming to other farmers in the region. Due to its outstanding success in dairy sector, the farm was awarded the title of "Milk Champion" in 2015 at the Dairy Mela organized by the National Dairy Research Institute, Karnal. Mr. Khokhar attributes the success of Arvind Dairy Farm to NDRI, other research and development organizations, and private companies. The family envisions expanding the farm with a greater number of high-quality pure H.F. breeds.

A. Banker

Commercial banks in India recruit graduates in agriculture and related fields as Agricultural Field Officers (AFOs) for promoting the banks' financial products and services like crop loans, insurance, or Kisan Credit Cards (KCC), to farmers and landlords in rural areas. Additionally, They are also employed by NABARD (National Bank for Agriculture and Rural Development), which is the apex bank for providing finance in rural development and regulating rural banks operating in India.

Success Story of Honey Production:

Mr. Jatinder Jeet Pal is a young honey entrepreneur of M/s Maghi Ram and Sons, located at Doraha, Ludhiana, Punjab. The brand name of his honey is "Samanyu Honey". Mr. Jatinder began his business in 2001 with 200 honey boxes after receiving comprehensive training in honey production from Punjab Agricultural University, Ludhiana. He has expanded his business beyond pure honey production (raw honey and blend honey) to include manufacturing of beekeeping equipments, such as honey processing plants, bee hives, honey extractors, pollen traps, and

grafting needles. Mr. Jatinder has been awarded with National level awards like Krishi Bhushan award from the Maharastra Government and Parman Patra from the Punjab Government. 'Samanyu Honey' from Maghi Ram & Sons is being exported to USA, Middle East, and Japan with an annual turnover of Rs.15-20 crores.

U. Organic Farmer

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Excessive use of agro-chemicals like fertilizers or pesticides can damage human health and the environment. As a result, consumers today prefer to buy organic products, which are free from harmful chemicals. Organic products are sold at higher prices than conventional ones, making organic farming a lucrative career choice in present times. An organic farmer performs agricultural operations similarly to a traditional farmer but focuses on minimizing the use of synthetic agrochemicals as much as possible.

Success story of a organic farmer:

Atinderpal Singh started turmeric cultivation in 2019 with the primary aim of processing and catering to local demand. Having completed his Master's in Agronomy from PAU, Ludhiana, Singh began growing, processing, and selling his produce directly in the local market, following a direct farm to kitchen model. Instead of relying on the chemicals for pest and weed management, Mr. Singh employs cultural as well as biological methods. In Punjab, where breaking away from the wheat-paddy cycle is difficult, he has successfully adopted crop diversification and moved away from water intensive paddy. He noted that after shifting away from paddy, beneficial animals like wild rabbits, quails, pheasants, red-wattled lapwings etc. had returned to the fields, a sign he sees as restoring ecological balance. The crop is grown, processed, and packaged on the farm and is sold at the farm gate. Starting with 2 acres of turmeric cultivation, he now cultivates 10 acres and sells it directly to end consumers. The farmer takes great pride in stating that his crop is pesticide and adulterant-free. Recounting his experience, he states that after initial difficulties in selling his crop, all his produce now sells directly from the farm gate itself. Economically, the initial cost of setting up the processing plant was 12 lakh rupees. In the first year, he generated a gross income of 3-4 lakhs, which has now increased to 20-22 lakhs. The farmer has been awarded several times for his crop diversification efforts by the Department of Agriculture and Farmers Welfare, Punjab.

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Success story of Fox Nut/Makhana production:

Sumitra Foods was co-founded in 2019 by Er. Ruchi Mandal and Er. Shravan Kr. Roy. They are driven by three strong objectives: empowering underprivileged women through training and employment, fostering an entrepreneurial mindset, and revolutionizing the Makhana processing industry. Shravan's interest in Makhana processing during his B.Tech in Food Process Engineering at the Indian Institute of Food Processing Technology sparked his vision for its global market potential. In 2019, Shravan left his corporate job and returned to Darbhanga, Bihar, to establish a Makhana processing unit. He convinced Ruchi, who was working with Samsung India Limited, to join him. With their personal savings, they launched Sumitra Foods, specializing in high-quality customized Makhana products. The enterprise's process involves handpicking raw Makhana seeds from ponds and processing them to meet clients' specific requirements. Sumitra Foods operates on a pan-India level, serving both B2B (Business to Business) and B2C (Business to Consumer) markets.

Sumitra Foods actively empowers women by providing employment opportunities and training in various aspects of food processing. The enterprise utilizes social media platforms such as WhatsApp, Facebook, and LinkedIn for effective marketing. The primary objective of Sumitra Foods is to cultivate an entrepreneurial mindset among daily wage workers, particularly women from financially disadvantaged backgrounds. They extend their support on a national scale by providing comprehensive training and supplying raw Makhana to women who express interest in establishing their own processing units. In 2020, Sumitra Foods had the honor of representing Bihar at the prestigious Organic Food Festival held in New Delhi. Their commendable efforts were recognized, and the enterprise was honored with the Tally MSME Honours in 2021.

Sumitra Foods is dedicated to establishing Makhana as a globally recognized agricultural product through their emphasis on women empowerment, transformative Makhana processing techniques, and promotion of entrepreneurship. The enterprise has emerged as a prominent player in the industry, driven by its unwavering commitment to quality, innovation, and social impact. By incorporating sustainable practices and fostering inclusive growth, Sumitra Foods not only contributes to the expansion of the Makhana industry but also uplifts underprivileged women and marginalized communities. This success is evidenced by their achievements in enhancing product value, creating employment opportunities, and fostering socio-economic development.

Fig. 25.9: Makhana packaging by local women and men

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INTEXT QUESTIONS 25.3

1. The person who acts as a bridge between laboratory and land is known as ....
2. Plant protection specialists are also known as ....
3. Who undertakes the preservation, protection and management of forests?
4. What are the roles and responsibilities of a food inspector?

ACTIVITY 2

Visit nearby Krishi Vigyan Kendras (KVKs) or Block Agriculture Office to inquire about the types of crops generally grown in your locality. Additionally, collect agriculture related books or pamphlets written in your mother tongue.

....

....

....

WHAT YOU HAVE LEARNT

- As agriculture is such a broad discipline, agricultural experts have many options where they might work, including academia, research, crop production, crop protection, marketing, sales, farm engineering, and farm management.

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- In India, there are numerous public and private universities that offer undergraduate, post-graduate and Ph.D. degrees in agriculture and allied disciplines.
- Common undergraduate degrees offered in the field of agriculture include Bachelors in Agriculture, Horticulture, Veterinary Science, Fishery, Community Science, Agricultural Engineering, and Dairy Technology.
- There are plenty of jobs in the agriculture sector, including roles such as agronomist, commercial horticulturist, farm manager, agricultural chemist, veterinarian, agricultural economist, extension worker, hatchery manager.

TERMINAL QUESTIONS

1. Discuss the key skills and capabilities required for jobs in agriculture.
2. What entrepreneurial job opportunities exist in the agricultural sector?
3. What educational programmes are available to become an agricultural professional?
4. Explain the responsibilities of an agronomist. How do they contribute to the overall well-being and health of crops?
5. Discuss the role of agricultural extension specialists in improving the efficiency and productivity of farming operations. Provide examples of activities they undertake to support farmers.

ANSWERS TO INTEXT QUESTIONS

25.1

1. B.Sc. in Agriculture, B.Tech. in Agricultural Engineering, B.V.Sc. in Veterinary Science
2. Option d (Bachelor in Veterinary Science)
3. Four years

25.2

1. Option b (Agri-entrepreneur)
2. Option a (overall well being of crops)
3. Krishi Vigyan Kendras (KVKs), agricultural universities and research institutes, seed companies
4. True
5. Landscape horticulturists

25.3

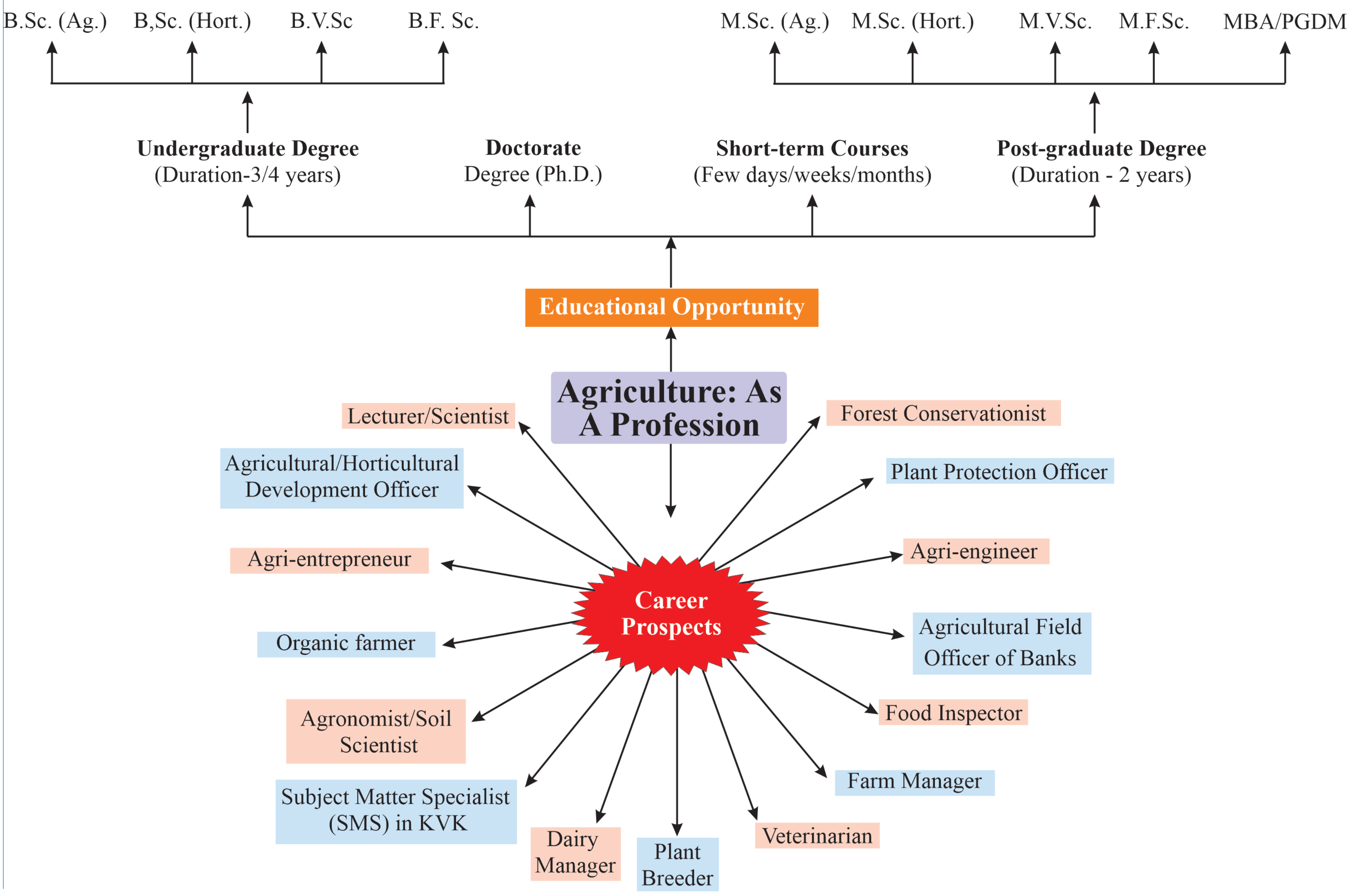
1. Village level extension workers
2. Plant health specialist or plant pathologist
3. Forester
4. To assure the safety and quality of the food products

GLOSSARY

Agricultural Entomology: Agricultural entomology is a branch of agriculture that focuses on the study of insects and their interactions with agricultural crops.

Apiculture: Apiculture, commonly referred to as beekeeping, is the art of raising honey bees for the purpose of producing wax and honey.

Plant Pathology: Plant pathology is the sub-discipline of agricultural science that involves the scientific study of plant diseases caused by pathogens such as fungi, bacteria, viruses.

Vermicompost: Vermicompost is the type of compost created by the decomposition of biodegradable wastes in the presence of earthworms.

WHAT YOU HAVE LEARNT